

UNHOLTZ-DICKIE CORPORATION

VIBRATION TEST SYSTEMS & MEASUREMENT INSTRUMENTATION

N347684-89

OPERATING INSTRUCTION MANUAL
MODEL D22PMS, SN 2750-2755

OPERATING AND SERVICING INSTRUCTIONS

MODEL D22 SERIES

SIGNAL CONDITIONING AMPLIFIER

MODEL D22PM_s

SERIAL NUMBERS 2750-2755

SUMMARY

CIRCUIT SCHEMATICS: B12362, B12522, C12496

F.S. TAPE OUTPUT: 0-10 V pk

F.S. GALVO OUTPUT: _____

L.P. FILTER (3 POLE) ±2% @ 5 kHz

-3dB @ 10 kHz

SPECIAL FEATURES: s

UNHOLTZ-DICKIE CORPORATION

3000 WHITNEY AVENUE

HAMDEN, CONNECTICUT 06518

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1. GENERAL DESCRIPTION

The U-D Model D22 Series Signal Conditioning Amplifier is a low-noise, solid-state, data-acquisition instrument. It generally supersedes the D11 Series instrument, and the provision of modular construction, a vinyl-clad case, self-contained power supply, and rear-mounted connectors make it equally suitable for single-unit bench operation or multi-channel rack mounting. The design makes extensive use of integrated circuits and plug-in circuit cards.

The D22PM is a basic charge amplifier which satisfies most general laboratory needs. The instrument accepts inputs from piezoelectric transducers to an internal charge converter or provides DC power to a remote two-wire preamplifier, and accepts the signal from the pre-amplifier. The remote preamplifier is either a Model 22CA-2 Charge Preamp or a Model 11PA-2 Voltage Preamp.

The D22 instrument includes a differential feature which permits separate ground systems for the amplifier input and output circuits. This allows the case of the input transducer to be grounded at the mounting location without introducing amplifier ground potentials at the signal output. This feature was pioneered in the earlier Model D11 Series instruments and has proven to be very useful for rejection of ground loop signals when the transducer case must be grounded.

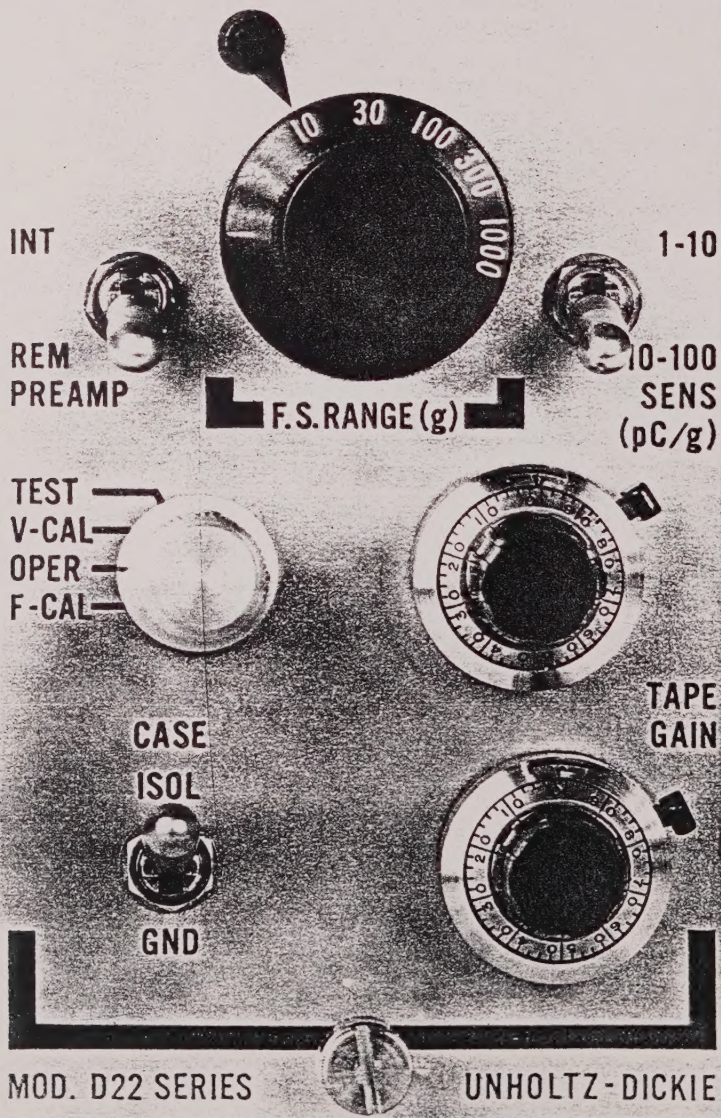
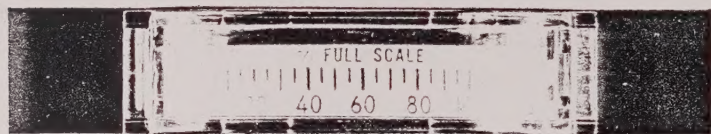
The input signal is conditioned to provide higher level outputs required for monitoring and recording purposes. A variable-gain, range-switched output is suitable for tape recording, spectrum analysis, oscilloscope monitoring or other readout with full scale condition from 0 to 10 Volts peak.



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CHARGE AMPLIFIER



Model D22PM Charge Amplifier

2. CONTROLS - CONNECTORS

The front panel controls are shown in Fig. 2.1 and the rear panel details are shown in Fig. 2.2. All two-position toggle switches are locking and must be pulled out to switch to the other position. The following descriptions are intended to cover all the standard features of the basic D22PM as well as the commonly-used servo and galvo options.

2.1 Front Panel Controls (Fig. 2.1)

- 2.1.1 SENSITIVITY RANGE SWITCH (1-10), (10-100). This two position toggle switch establishes the range for the sensitivity of the accelerometer being used. The units are pC/g, pC/psi, or pC/engrg unit, depending on whether the transducer is an accelerometer, pressure gage, force gage or other.

Full scale output ranges can be extended by a factor of ten in the lower direction by using an accelerometer in the 10-100 range and intentionally placing the range switch in the 1-10 position. All indicated full scale range values are then divided by 10.

Similarly, the full-scale output ranges can be extended by a factor of ten in the upper direction by using an accelerometer in the 1-10 range and intentionally placing the range switch in the 10-100 position. This is especially useful for high-g shock work and all range values are multiplied by 10.

- 2.1.2 SENSITIVITY DIAL. This ten-turn dial with locking brake and potentiometer is used to set the significant figures of the transducer sensitivity within the ranges indicated in 2.1.1. The dial can always be set between 1.0 and 10.0 and also somewhat above 10.0 and below 1.0 depending on the requirements of individual users. The setting and reading accuracy is about 1% at 1.0, and 0.1% at 10.0 (one-half of one small scale division).

If either the internal or external charge converter is used, the charge sensitivity in pC/g specified on the accelerometer data sheet is set directly on the SENS. dial and RANGE.

- 2.1.3 FULL SCALE RANGE. A rotary switch having the full scale range values engraved on the skirt of the knob. The switch has seven positions from 1 g to 1K g and the pilot light near the arrow indicates a power on condition.
- 2.1.4 TAPE GAIN. A ten-turn potentiometer with a direct reading turns-counting dial and locking brake, which varies the full-scale tape driver output from 0 to 10 V peak. Setting the TAPE GAIN at less than 100% (10 turns) causes a lower

full scale output but allows a larger overdrive capability without clipping at the tape output. For example a setting of 2.0 V pk will allow 5 times overdrive beyond full scale condition without clipping for all except the highest full-scale range position.

- 2.1.5 ~~GALV. GAIN (Option G) A ten-turn potentiometer with a turns-counting dial and locking brake, with a function identical to that of the TAPE GAIN except that it applies to the GALV. output.~~
- 2.1.6 CASE ISOL.-GND. A two-position toggle switch which selects the proper mode of operation with accelerometers which have the case isolated from the test specimen or the case common to the electrical ground at the test specimen. When the transducer case is isolated, use the ISOL. position. When the transducer case is grounded, use the GND position.

The pilot light provides a convenient means for proper selection if the grounding condition is not known. The pilot light state chart shows the possible combinations.

Pilot Light State Chart (Condition)		TRANSDUCER CASE CONDITION	
		ISOL	GND
SWITCH	"ISOL"	ON	ON
POSITION	"GND"	OFF	ON

If the light remains on in both switch positions, choose the GND position for the switch. If the light is on only in the ISOL position, leave the switch in the ISOL position.

- 2.1.7 MODE SWITCH. A four-position rotary switch which selects modes of operation or calibration. The descriptions of the four positions follow:

TEST - The shield of the transducer cable is connected to the OSC input. The oscillator voltage is fed to the charge converter through the capacitance of the cable and transducer. This provides a check of the cable and transducer integrity (if the shield or case is not grounded) by producing an output that is proportional to the source capacitance. A reference reading with a known 1000 pF capacitance can be obtained by first using the V-CAL mode described in the next paragraph.

V-CAL - The OSC input is connected through a 1000 pF $\pm 0.5\%$ capacitor to the input of the charge converter. All outputs depend on the SENS. and F.S. RANGE SWITCH settings. A 1 pC/mV conversion is provided by the capacitor.

OPER. - The CHARGE input is connected directly to the charge converter and the OSC is disconnected.

F-CAL - The OSC input is connected so that the SENS. and F.S. RANGE settings are disabled and an input signal of 100 mV peak provides full scale indication for METER, GALV. and TAPE outputs.

The TEST and V-CAL positions are not operative when a REMOTE PREAMP is used. Calibration connections with the remote preamplifiers is shown in Figure 4.1.

- 2.1.8 PREAMP. REM. - INT. A two position toggle switch. The REM. position is used for either the Model 22CA-2 or Model 11PA-2 remote preamp. The INT. position is used when the transducer is connected to the internal charge converter in the Model D22 Series.
- 2.1.9 FILTER. The low-pass filter in the D22PM instrument may be removed by extracting the small plug-in capacitor board from card 12311 after the top-cover of the Model D22 has been removed. The sub plug-in board should be marked with the filter frequency ($\pm 2\%$ point).
- 2.1.10 METER. The meter normally has a single scale calibrated in per cent of full scale from 0 to 120%. Dual meter scales (0-3 and 0-10) for exactly 10 dB range switching can be supplied when the 10 dB range switching option has been specified. The meter movement responds to the absolute average value of the input signal and the meter scale is calibrated in terms of the peak value of a sinusoidal input signal.

2.2 Chassis Screwdriver Adjustments

These potentiometer adjustments are made from access holes located on top of the chassis and are appropriately marked. Adjustment is generally made only during periodic calibration checks.

- 2.2.1 ACC - For instruments with the SERVO output (Option S) this trimming potentiometer is used to adjust the output calibration constant to 10 mV/g. This adjustment is made before the METER adjustment is made.

For the basic instrument with no SERVO or GALV outputs, the ACC adjustment is set so that the full scale tape output is obtained for a calibration signal corresponding to the full scale value indicated by the F.S. RANGE switch.

- 2.2.2 F-CAL - The MODE switch must be in the F-CAL position before this adjustment is made, and 100 mV peak is applied to the OSC input. The F-CAL pot. is adjusted for full scale output at the tape output.
- 2.2.3 METER - This adjustment is made to provide full scale meter deflection when a calibration voltage corresponding to the full-scale value indicated by the F.S. RANGE switch is applied to the OSC input.
- 2.2.4 ~~OSC (Option O) - This adjustment is used to set the internal 100 Hz calibration oscillator signal to 100 mV peak. The internal oscillator signal can be monitored at the PATCH connector for this adjustment.~~

2.3 Internal Screwdriver Adjustments

These potentiometer adjustments can only be made by removing the top cover of the chassis. They have been carefully set at the factory and should only be readjusted if a malfunction is suspected. These adjustments are described for each printed circuit card.

- 2.3.1 DIAL-A-GAIN AMPLIFIER (PC BD12307) The BAL potentiometer is used to adjust the DC output of the card to a slightly positive voltage for a SENS. DIAL setting of 1.0 and no signal input. The voltage can be monitored on pin 4 when the bottom cover has been removed to expose the connector pins.

The CURR ADJ. potentiometer is used to set the constant current excitation for the remote preamp at 5.3 mA. This can be measured by placing a milliammeter across the REMOTE PREAMP input.

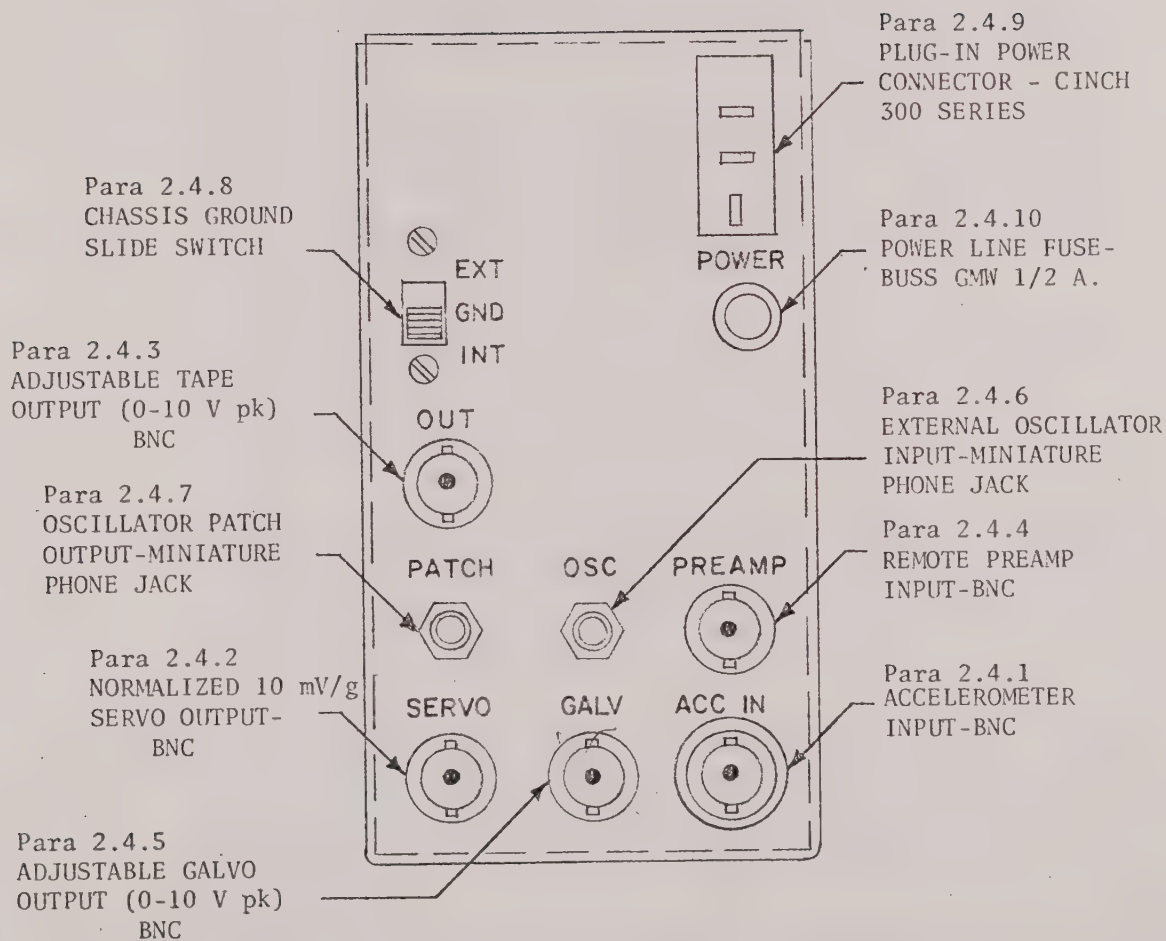
- 2.3.2 DIFF AMP. - L.P. FILTER - TAPE (PC BD12311) The NULL potentiometer is used to adjust the ACC output of the instrument to a minimum when a test signal is inserted between the shell of the ACCEL IN connector and the shell of the OUT connector. The CASE switch must be in the GND position. In this way rejection of ground difference potentials is accomplished.

The BAL potentiometer is used to adjust the DC voltage at the tape output to zero for direct coupling. The output may be monitored on pin 2, or at the rear OUT connector.

The GAIN potentiometer is used to adjust the tape output to the specified full scale value for a TAPE GAIN setting of 100%, and a calibration voltage input equal to the full-scale value indicated by the F.S. RANGE Switch. This adjustment is always made after the ACC adjustment for the SERVO (10 mV/g) is done.

- 2.3.3 SERVO-METER (PC BD12373) The BAL potentiometer is used to null the output of the first stage of the converter (point A) for zero signal input.

The ZERO potentiometer is used to null the output of the last stage of the converter (point B) after the BAL adjustment is made. These adjustments are critical only when wide-range DC outputs are needed.



REAR PANEL - MODEL D22PMGS

FIGURE 2.2

2.4 Rear Panel Features (Fig. 2.2)

- 2.4.1 ACC IN An insulated BNC connector for accepting the signal from a piezoelectric transducer. It is the input to the internal charge converter. A Microdot 33-101 adapter can be used to provide compatibility with low-noise cable and a Microdot connector. The PREAMP switch must be in INT. position.
- 2.4.2 SERVO (Option S) An insulated BNC connector providing an output voltage with the calibration constant of 10 mV/g.
- 2.4.3 OUT An insulated BNC connector providing an output voltage of 0-10 V pk for inputs corresponding to the full scale value indicated on the F.S. RANGE switch and a peak current limited at ± 10 mA. The full scale output level is controlled by the front panel TAPE GAIN potentiometer.
- 2.4.4 PREAMP An insulated BNC connector for accepting the two-wire connection (shield and center conductor) to the Model 22CA-2 or Model 11PA-2 external preamps. This connector is active in the REM position of the front panel PREAMP switch.
- 2.4.5 ~~GALV. (Option G) An insulated BNC connector providing an output voltage of 0-10 V pk for inputs corresponding to the full scale value indicated on the F.S. RANGE switch. The output current is limited at ± 100 mA. The full scale output level is controlled by the front panel GALV GAIN potentiometer.~~
- 2.4.6 OSC A miniature phone jack for accepting an external calibration signal. If an internal oscillator (option O) is located within the module, it is automatically disconnected when the external signal is plugged into the OSC jack. A mating plug is supplied with the instrument.
- 2.4.7 PATCH A miniature phone jack for patching the calibration signal on to the next channel. The PATCH jack for channel #1 is connected to the OSC jack for channel #2, etc. The mating phone plug is Switchcraft TINI-PLUG #780 for both jacks. Patch cords are supplied with the instrument.
- 2.4.8 EXT GND - INT GND. A two position slide switch that connects the output circuit signal ground to the chassis in the INT GND position and leaves the signal ground floating in the EXT. GND. position.

If signal ground is common to chassis in the external instrumentation, the EXT. GND. position may generally be used. However, if the third wire in the power cord

is not carried to the power line ground at the socket and the chassis is not electrically common to other chassis in the system, the INT. GND. position should be used. The INT. GND. position should also be used if signal reference is not connected to chassis in the external instrumentation.

In a practical sense, the switch position should be used that shows the minimum amount of power frequency pickup with an oscilloscope monitoring the output(s) of interest.

2.4.9 POWER A three-pin connector which mates with the 22RA rack adapter power strip or the individual line cord.

2.4.10 FUSE - Bussman GMW 1/2A.

3. OPERATION

All toggle switches must be pulled out to switch.

3.1 General Procedure

3.1.1 Internal or Remote Preamp

Place the PREAMP switch on the REM position if the instrument is to be used with a remote two-wire preamp (Model 22CA-2 or 11PA-2) in the vicinity of the transducer. If there is a direct connection between the Model D22 and the transducer, use the INT position.

When the internal mode has been chosen, it is recommended that low-noise, subminiature microdot cable is used whenever possible. Connection is made to the ACC IN BNC by means of a Microdot 33-101 adapter (supplied by user). Standard RG/U cable instead of low-noise cable may be used, but extreme care in routing must be exercised, since it is often more than 100 times more sensitive to cable motion in generating electrical noise voltages (triboelectric effect).

When the remote preamp mode has been chosen, use standard RG/U cable or other two-wire cable to connect the remote preamp to the PREAMP connector. Cable lengths up to 2000 feet can be used between the remote preamp and Model D22 Series. The low impedance level of the driving source makes the circuit insensitive to cable motion.

3.1.2 Other Front Panel Settings

CASE	- ISOL or GND See Section 2.1.6	
SENS. RANGE	- See Section 2.1.1	} Determined by Transducer
SENS. DIAL	- See Section 2.1.2	
F.S. RANGE	- To range value greater than highest measurement expected	

3.1.3 Filtering

Check the low pass filter condition stated on the manual front cover and title page as shipped from the factory. If changed by customer, make sure of the conditions of the low-pass filter sub plug-in board on PC CARD 12311. The filter is active when the small sub plug-in board containing three capacitors is installed. The customer may desire to mark the filter frequency at a convenient location on the front panel if the filter condition is changed periodically.

3.1.4 Output Connections

Connect the OUT, GALV and SERVO outputs to the readout or control equipment as required. See Section 2.4.8 for recommendation for setting the INT GND-EXT GND Switch.

- 3.1.5 Apply line power by plugging in the instrument individual line cord or by applying power to the Model 22RA Rack Adapter housing the instruments. Make certain the front panel pilot light is ON. If the light is not on, consult Section 2.1.6 and then check the FUSE.
- 3.1.6 Adjust the TAPE GAIN and/or GALV GAIN as required. Remember that the dial setting provides a calibrated full scale output in terms of AC volts pk. For instance a setting of 1.00 provides 1.0 V pk at full scale conditions.
- 3.1.7 Monitor and record test data as required.

3.2 Full Scale Output Check

- 3.2.1 Patch all channels to the channel with the internal oscillator (master) by connecting the PATCH jack of the master channel to the OSC jack of the next channel and continue this connection from channel to channel. If the internal oscillator is not present, designate channel #1 as the master channel and apply 100 mV peak at 100 Hz to the OSC jack of that channel. Six channels can be supplied from one channel with an internal oscillator (Option O).
- 3.2.2 Set MODE SWITCH to F-CAL
 TAPE GAIN to desired value (Section 2.1.4)
 GALV GAIN to desired value (Section 2.1.5)
 Monitor desired outputs
- 3.2.3 Apply line power and allow at least a minute for warmup.
- 3.2.4 Check outputs for expected values.

3.3 Integrity Test For Input Cable and Transducer

This test can be carried out when the transducer is operating with the internal charge converter and when the transducer case is ISOLATED from ground at the mounting location.

- 3.3.1 Provide the following connections and settings:

Connect input transducer (Section 2.1.1)

Provide 100 mV peak at OSC jack if option O is not available.

SENS. to 10.0
 F.S. RANGE to 10
 MODE to V-CAL

Apply power, allow at least a minute warmup.

- 3.3.2 Determine the full scale output at the OUT BNC, GALV BNC, or the meter indication (O_{FS}).
- 3.3.3 Switch MODE to TEST. Record OUTPUT (O_T) and F.S. RANGE (R_T). It may be necessary to change the range.
- 3.3.4 Total capacitance of cable and accelerometer is given by:

$$C_C + C_a = \frac{R_T \times O_T}{10 \times O_{FS}} \times 1000 \text{ pF}$$

NOTE: Complete

VARIABLE OSCILLATOR

2 Hz to 50 kHz

KROHN-HITE Model 4100R

TRANSDUCER
(optional)

Shielded Enclosure

1000 pF $\pm \frac{1}{2}\%$

Required for
22CA-2 only

Required for
22CA-2 only

Model 22CA-2 Remote
Charge Preamp
or
Model 11PA-2 Remote
Voltage Preamp

10

del 11PA-2 Remo
Voltage Preamp

OPTIONAL ATTENUATOR
GERTSCH RATIO-TRAN
Model RT-7C or equal

Model RT-7C or equal

IN / OUT

OPTIONAL
SWITCHING
PANEL

ACC IN
Charge
Input

PREAMP
Input

Input

Output

Tape
Output

Output

U-D CORP., MODEL D22PMGS

SIGNAL CONDITIONING AMPLIFIER

ELECTRONIC VOLTMETER

HP Model 3403A
or equal

OSCILLOSCOPE

HP Model 1200B
or equal .

4. CALIBRATION - CHECKOUT

4.1 Routine Gain Calibrations

The adjustments in para. 4.1.4, 4.1.5 and 4.1.6 are the only routine calibration adjustments that are required for maintaining instrument gain accuracy. Any changes of more than 1% would suggest the need for instrument repair or a check of the procedure and connections being used.

4.1.1 Instrumentation Set-Up

Connect the instrumentation as shown in Fig. 4.1. A precision step-attenuator such as a Gertsch Ratio-Tran Model RT-7C, or equal, can be inserted between the oscillator and D22 Series instrument to facilitate range switch accuracy checks.

The use of the V-CAL mode for calibration automatically places a precision 1000 pF capacitor in series with the input charge converter.

The series calibration-capacitor that is required when calibrating the Model 22CA-2 Remote Charge Preamp must be completely shielded and connected to the input of the Model 22CA-2 by means of a low-noise shielded cable.

Always use the oscilloscope to monitor waveform purity, avoid ground loops between input and output circuits and follow recommendations in 2.4.8 for the INT. GND. EXT. GND. switch.

4.1.2 Charge Input (ACC IN BNC)

It is not necessary to have a cable or transducer connected to the charge input for the standard calibration checks. For low level checks the connection may be covered with a shielded cap, but the center conductor cannot be shorted to the shield or ground.

4.1.3 Instrument Settings

PREAMP	- INT.
MODE	- V-CAL
CASE	- ISOL.
TAPE/GALV GAIN	- 10 TURNS (MAX)
SENS	- 10 (RANGE 1-10, TURNS = 10)
F.S. RANGE	- 10 g
Audio Oscillator	- 100 mV peak (70.7 mV rms) @ 1 kHz
	Connect to OSC input miniature phone jack.

NOTE: The following calibration adjustments, when required, are made from access holes located on top of the chassis as described in Section 2.2.

- 4.1.4 SERVO (10 mV/g) Output (Option S)
Attach CRO and ACVM to SERVO connector.
Adjust ACC potentiometer to provide 100 mV peak (70.7 mV rms)
- 4.1.5 Meter Adjustment
Adjust METER potentiometer to provide 100% full scale meter indication.
- 4.1.6 F-CAL Adjustment
Change MODE switch to F-CAL position.

Adjust F-CAL potentiometer for exactly 100% full scale indication of the meter. Changing F.S. RANGE or SENS settings should not affect the meter indication.

- 4.2 Gain Check (Non-routine Adjustments) - These adjustments have been set carefully at the factory and should not require routine adjustment.

- 4.2.1 Tape and Galvo Outputs
Attach CRO and ACVM to tape OUT and/or GALV connector. After the SERVO adjustment of para. 4.1.4 has been made, and with the settings as described in para. 4.1.3, the tape and galvo outputs should be 10 V pk (7.07 V rms) $\pm 1\%$.

If either the tape or galvo output requires readjustment, the internal GAIN pot located on PC Board 12311 (as described in para. 2.3.2) must be readjusted. Consult para. 5.3.3 of the Maintenance-Servicing Section for further instructions.

- 4.2.2 Sensitivity Dial Offset

This adjustment has been set carefully at the factory and should not require routine adjustment.

- 4.2.2.1 Use settings in 4.1.3
- 4.2.2.2 Adjust TAPE GAIN to provide 1.00 V rms $\pm 1\%$
- 4.2.2.3 Decrease oscillator voltage to 10 mV peak (7.07 mV rms). Set SENS DIAL at 1.00.

The output voltage should be 1.00 V rms $\pm 1\%$.

- 4.2.2.4 If the output voltage is too high (low) in 4.2.2.3, turn SENS. DIAL CCW (CW) until the stop is reached. Note the reading on the dial. Loosen the set screw on the knob and decrease (increase) the dial setting by one minor division for each 2% error in 4.2.2.3. Lock the setting, replace the dial and tighten the set screw, taking care not to move the shaft off the stop.

One adjustment is usually sufficient if the offset measurement is inaccurate by only a few percent.

4.3 Maximum Output Check

4.3.1 Instrument Settings

SENS - 10 (RANGE 1-10, TURNS = 10)
 F.S. RANGE - 1000 (1K) g
 PREAMP - INT.
 MODE - V-CAL
 TAPE/GALV GAIN - MAX. (10 TURNS)
 CASE - ISOL
 Audio Oscillator - 10 V peak (7.07 V rms) @ 1 kHz

4.3.2 The OUT, GALV, and/or SERVO signals should not show clipping or distortion at the peaks.

4.4 Full Scale Range Switch Accuracy Check

4.4.1 With the settings in 4.3.1 adjust the audio oscillator output to 1.00 V rms. The TAPE output should be 1.00 V rms at full CW rotation when on the 1K g Full Scale Range

4.4.2 Adjust the oscillator voltage according to the following table for associated F.S. RANGE settings. The tape OUT signal should be 1.00 V rms $\pm 1\%$ for all F.S. RANGE settings. The Gertsch Ratio-Tran can be used to change voltage inputs for this procedure.

Oscillator (V rms)	F.S. RANGE
1.00	1K
.300	300
.100	100
.030	30
.010	10
.003	3
.001	1

Note: It is essential that input circuit ground loops be avoided in order to prevent errors when performing the lower level measurements. A clean, ripple-free waveform should appear on the scope for all check points. It may be necessary to place a shielded cap (not shorting) on the "ACC IN" BNC for the lowest reading.

4.5 Frequency Response Check

- 4.5.1 Instrument Settings - same as 4.3.1 except the oscillator output is set at 1.00 V rms. The tape OUT signal should be at 1.00 V rms for this combination of settings.
- 4.5.2 The percentage variations of the tape OUT signal should remain within the tolerances shown in the following table at the frequencies shown for the low pass filter condition supplied and for the "filter out" condition (sub plug-in board removed).

Frequency (Hz)	2	5	10	100	1K	5 K	10K	30K
w/LP Filter Supplied	±5%	±2%	±1%	REF	±1%	±2%	-3dB ±1dB	
w/LP Filter Unplugged	"	"	"	"	"	± %	± %	±5%

Note:

- Below 10 Hz, input and output measurements should be made on a direct-coupled oscilloscope.
- The small, sub plug-in board with 3 capacitors that determines the low pass filter condition is described in para. 2.1.9 and Fig. 5.5.

4.6 Noise Check

The noise measurements are made at an instrument gain of 1000 mV/p

4.6.1 Instrument Settings:

SENS - 1.00 (1-10 range)
 F.S. RANGE - 1 g
 PREAMP - INT
 MODE - OPER
 TAPE GAIN - 1.00 (1 TURN)
 CASE - ISOL

Connect 10 ft low noise cable and a shielded 1000 pF capacitor to the ACC IN BNC connector.

The maximum noise reading at the OUT connector should be less than 7 mV rms (.007 pC rms RTI). The noise on the scope should appear as basically random with an absence of pronounced power line frequencies.

- 4.6.2 With a Model 22CA-2 or Model 11PA-2 remote preamp, change the PREAMP switch to REM and connect a shielded 1000 pF capacitor across the input to the remote preamp. With the remaining settings in 4.6.1, the output noise should be
- with Model 22CA-2 - 8 mV rms (.008 pC rms RTI)
 with Model 11PA-2 - 40 mV rms (40 μ V rms RTI)

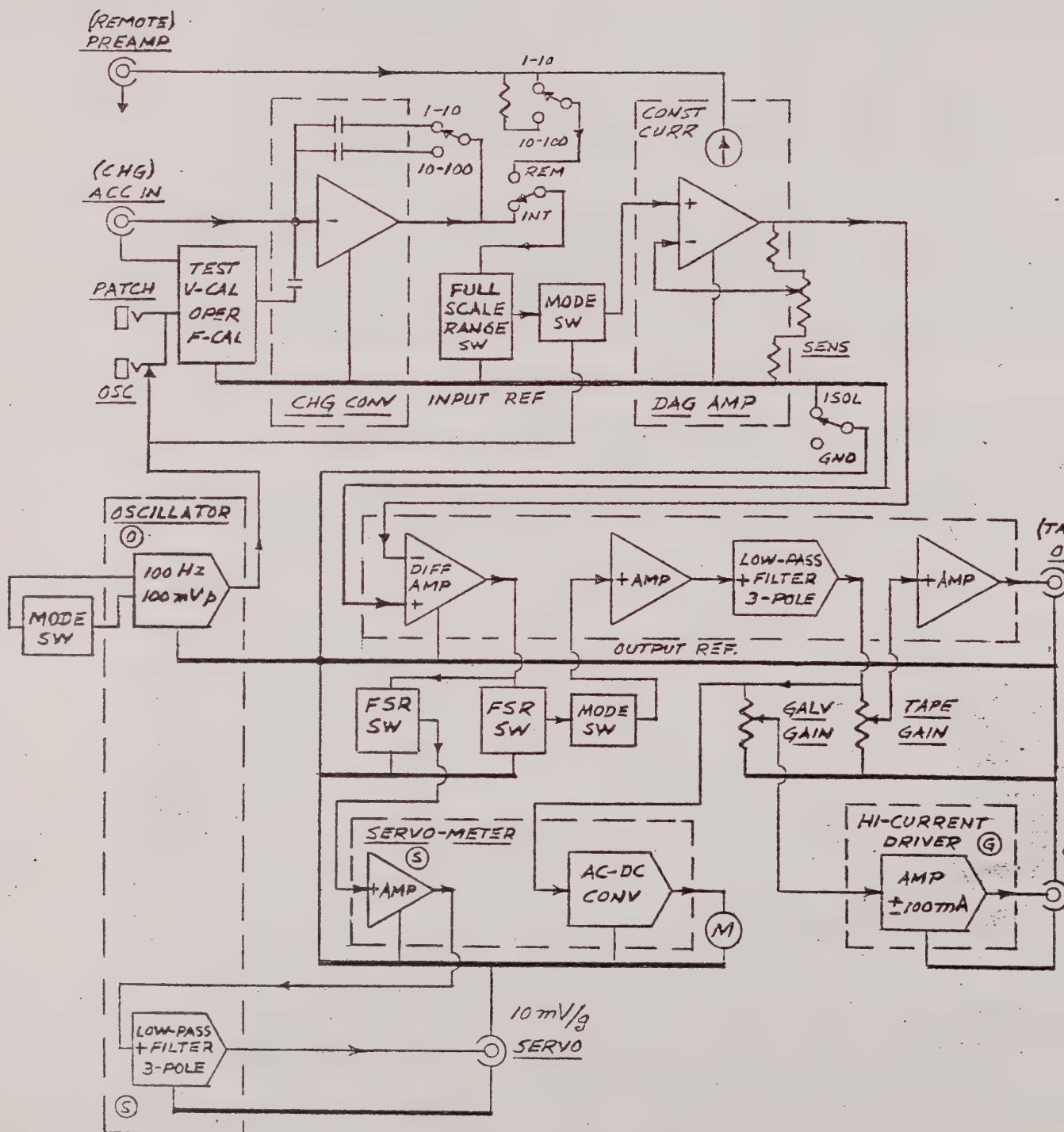


Figure 5.1
Simplified Block Diagram
MODEL D22PM(G) (S) (O)

5. MAINTENANCE-SERVICING

5.1 Block Diagram

As an aid to understanding the operation of the Model D22PM, a simplified schematic/block diagram is shown in Fig. 5.1. The complete schematic is found in Dwg. No. C12496.

5.2 Chassis Layout

The layout of the chassis cards is shown in Fig. 5.2. The view is from the top of the chassis with the top cover removed.

5.3 Access for Servicing

5.3.1 Visual Inspection

Although normal calibration and checking procedures may be accomplished from the outside, as noted in Section 4, it may occasionally be necessary to inspect the printed circuit cards or the connector wiring for possible causes of intermittent problems or suspected failures.

The top cover may be taken off by first removing three screws on the top of the chassis at the front and rear. The cover may then be pulled up and off. To replace, slide the sides of the top cover in the groove formed by the bottom cover and the card tray and replace the screws. The removal of the top cover gives access to the printed circuit cards (except the charge converter card as described in the following para.).

5.3.2 Charge Converter Card

The charge converter card is enclosed by shields that are electrically isolated from the chassis. The bottom shield partially covers the connector contacts, and the top shield covers the charge converter card and is attached to the card by standoffs. Two screws must be removed from the underside of the card tray to permit extraction of the charge card from the connector. Both shields are electrically connected to the input reference (signal ground).

The assembly not only provides the necessary rigidity for the charge converter card but also shields critical portions of the circuit from electrical pickup.

The charge converter card and the attached shield are removed by first removing the two shield mounting screws and then pulling the assembly from the connector. The card and upper shield are separated by removing two screws from the side of the shield.

5.3.3 Internal Adjustment Pots

The DIAL-A-GAIN AMPLIFIER BAL pot and the remote preamp CURRENT ADJUST POT (Figure 5.4) and the METER BAL & ZERO pots (Figure 5.6) can be adjusted at the top of the appropriate card.

The DIFF AMP NULL pot (Figure 5.5) can be reached from above by inserting a screwdriver between two cards.

The tape 10K ohm BAL and 200 ohm GAIN pots (Figure 5.5) can be readjusted by using one of the following techniques:

- 5.3.3.1 Trial and Error Approach - remove the PC Board, rotate the pot, replace the board, check the output, and repeat if necessary.
- 5.3.3.2 Use Right-angle Adjustment Tool - a crude right angle adjustment tool can be made to reach between the PC Boards to change the GAIN or BAL pot settings. This tool can be made by flattening the ends of a piece of 14 AWG bus bar and bending at 90° angles. This item can be ordered as a D22 Series Adjustment Tool.
- 5.3.3.3 Use Extender Card - a single sided PC Board extender card can be ordered as a D22 Series Single Sided Extender Card. When the PC Board is removed to be placed on the extender card, caution must be taken to place the PC Board on the extender card facing in the proper direction, since the index keys are no longer functional.

5.4 Voltage Measurements

Table 5.1, which follows, gives typical voltage throughout the instrument. Large deviations usually indicate a malfunction.

It is assumed that no accelerometer is connected and the CASE switch is in the ISOL position. Use a 20,000 ohm/volt multi-meter for the measurements (Simpson Model 270; Triplet Model 630-NA). Reference Figure 5.2 for PC card description and location.

CARD	TERMINAL(S)	VOLTAGE
OUTPUT POWER SUPPLY	1-2	20 ± 4 V AC rms
OUTPUT POWER SUPPLY	1-3	20 ± 4 V AC rms
OUTPUT POWER SUPPLY	10-6 (REF)	$14.5 \pm .5$ V DC
OUTPUT POWER SUPPLY	9-6 (REF)	$14.5 \pm .5$ V DC
INPUT POWER SUPPLY	1-2	25 ± 4 V AC rms
INPUT POWER SUPPLY	1-3	25 ± 4 V AC rms
INPUT POWER SUPPLY	10 *	$21 \pm .5$ V DC
INPUT POWER SUPPLY	9	$21 \pm .5$ V DC
CHARGE	H	$0 \pm .010$ V DC
DIAL-A-GAIN AMPLIFIER	8	0 ± 0.5 V DC
DIFF-LP FILTER - TAPE	3	0 ± 0.5 V DC
HIGH-CURRENT DRIVER	1	$0 \pm .001$ V DC
HIGH-CURRENT DRIVER	10-8	12 ± 2 V AC rms
HIGH-CURRENT DRIVER	9-8	12 ± 2 V AC rms

*All DC Voltage Measured Relative to Pin 6

TABLE 5.1

5.5 Servicing Malfunctions

The detailed calibration and checkout procedures in Section 4 and the voltage measurements in Section 5.4 should be of great help in pinpointing possible trouble. In addition, standard signal tracing techniques proceeding generally from input to output and making use of the oscilloscope are of great help.

The printed circuit cards are also removable, which helps locate short-circuit malfunctions.

If replacement of any component is necessary on a printed circuit board, the excess solder at the points of insertion should first be removed by either a soldering iron and a desoldering wick (Dri-wick-American Electrical Heater Co.) or a desoldering bulb (Ungar #7805 Solder-Off Bulb). Combinations of soldering irons and bulbs are also available (Ungar Model 7800 Hot-Vac Tool).

Removal of integrated circuits is best accomplished by using a special soldering iron tip designed to fit around the IC pins and an extractor. The excess solder around the insertion points is removed by the method of choice, and the IC pins are then straightened. The card is then clamped in a bench vise, the pins are heated with the special soldering iron tip (Princess 6902 Handle 6918 Heat Capsule, and 6948 tip) and the integrated circuit is pulled out with the extractor.

When the soldering wick is used, the integrated circuit may often be pried out carefully without the use of the special soldering tool.

Care should always be taken in removing components to avoid delamination of the conductor from the printed-circuit card.

5.6 Component Location

Figures 5. through 5. show the component layout for each of the circuit boards.

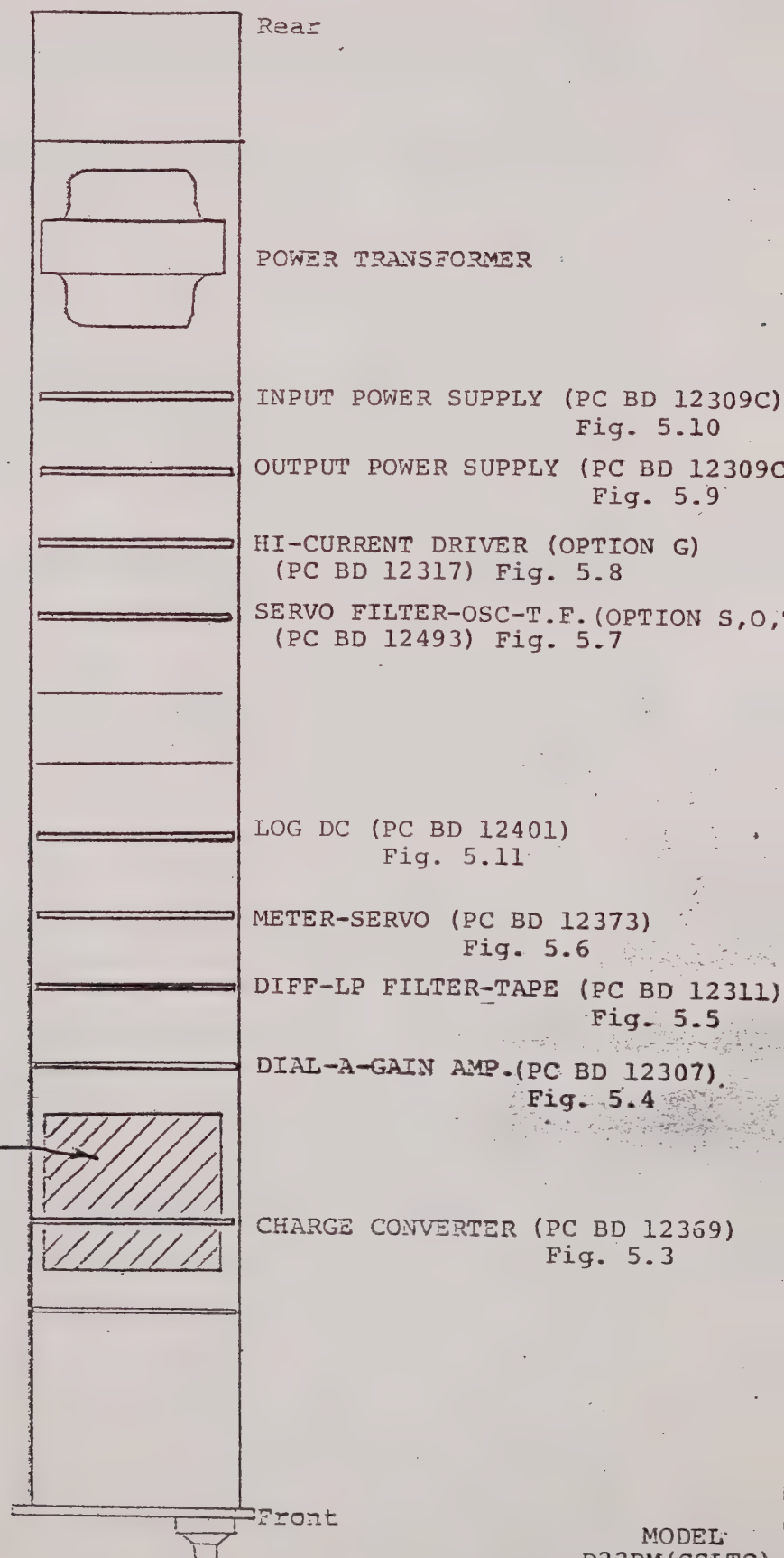
5.7 Following is ordering information for integrated circuits, semiconductors, and other critical components used in the Model D22PM. Other resistors and capacitors are available from standard distributor stock and are adequately identified on the PC Card layouts and circuit schematic diagram.

PART NO.	DESCRIPTION	MANUFACTURER
NE531V	I.C. Op. Amp	Signetics
LM301AN	I.C. Op. Amp	National, Raytheon
UGA7723393	I.C. Voltage Regulator	Fairchild (μ A723)
AD842	Dual FET	Analog Devices
T1S92 (G opt)	Si. NPN	Texas Inst.
T1S93 (G opt)	Si. PNP	Texas Inst.
2N4922	Power NPN	Motorola
2N4919	Power PNP	Motorola
1N5394	Si Rectifier	Westinghouse
U2320	N FET	Amelco/Teledyne
1N5312 (G opt)	Const Current Diode	Motorola
1000pF $\frac{1}{2}$ "	Mica Cap	General Inst./Miconics
2000pF $\frac{1}{2}$ "	Mica Cap	General Inst./Miconics
10000pF $\frac{1}{2}$ "	Mica Cap	General Inst./Miconics
33-101	BNC to Microdot Adapter	Amphenol
T-82	Power Transformer	U-D Corp.

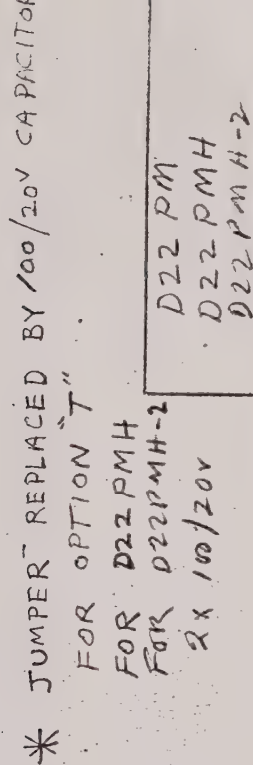
FIG 5.2 CHASSIS LAYOUT

Components on all
cards face rear

Metal deck in-
sulated from
chassis - Kept at
input reference
(charge conv.
cover removed)



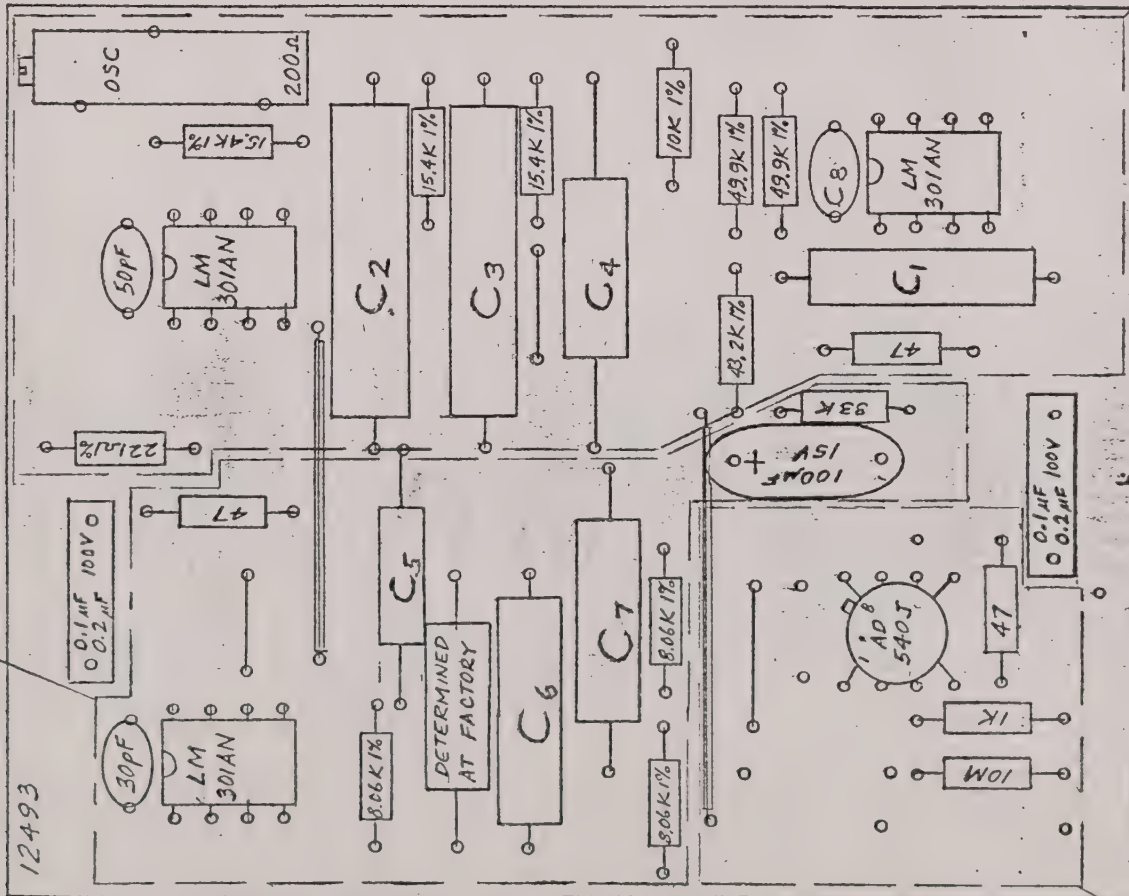
MODEL
D22PM(GSLTO)



TOLERANCES (EXCEPT AS NOTED)	UNHOLTZ-DICKIE CORP.
ORIGINAL	SCALE
2	DRAWING BY APPROVED BY
FRANCHISE	TU 1
2	
ANGULAR	DIAL-A-GAIN AMPLIFIER COMPONENT LAYOUT
2	DRAWING NUMBER
	9-13-72
	FIGURE 5.A

FIGURE 5.4

SERVO FILTER (DOES NOT APPLY TO 022FMMH)



	2 KHZ	5 KHZ	10 KHZ	4 KHZ	3 KHZ
C5	.001	39pF	200pF	500pF	680pF
C6*	.015	.005	.0022	.0068	.01
C7	.0068	.0027	.0012	.0033	.004

* ADJUSTED AT FACTORY

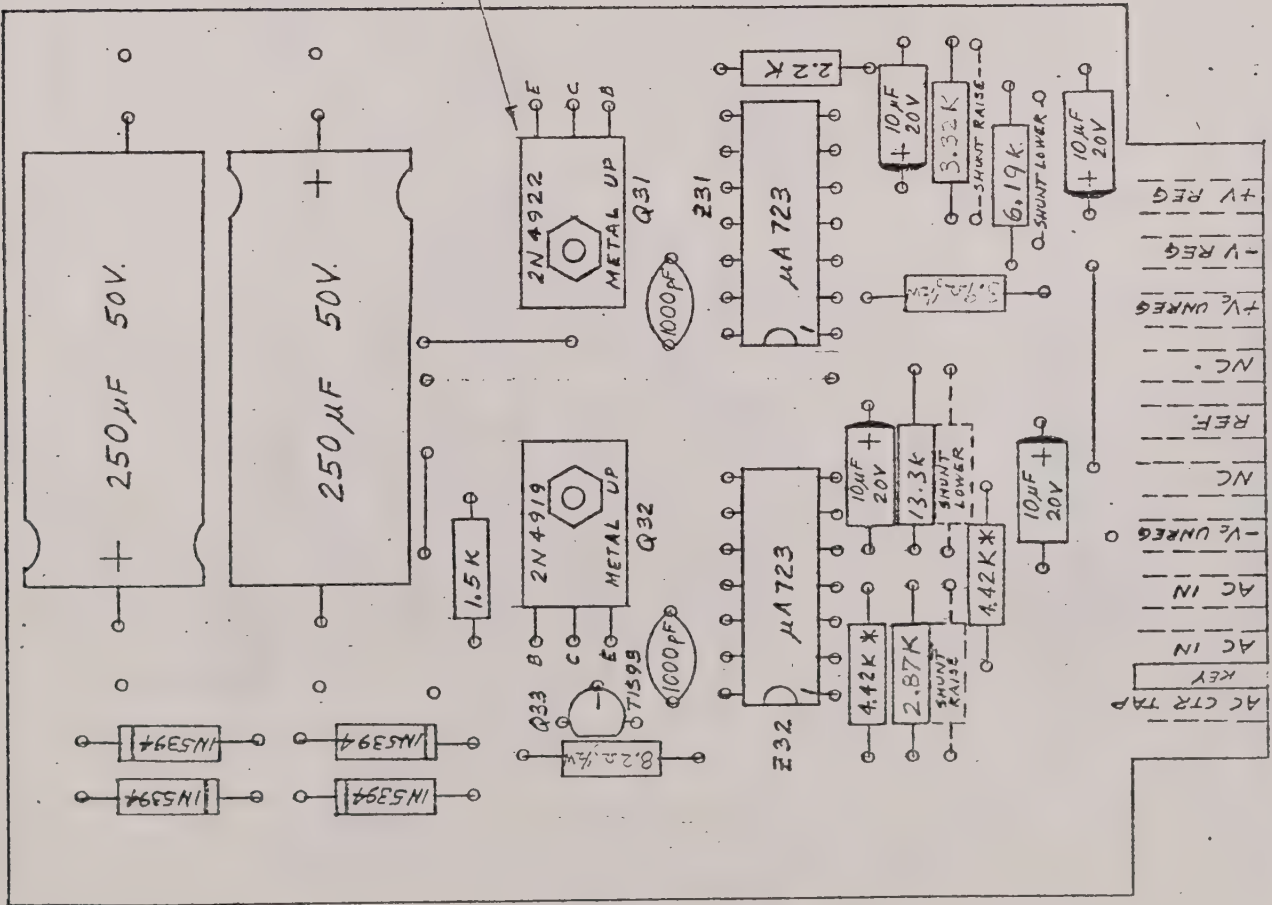
	100HZ	150HZ	200HZ	1KHZ
C1	.1	.068	.047	.01
C2	1.0	.68	.47	.1
C3*	.47	.33	.22	.047
C4	.015	.01	.0068	.0015
C8	200pF	200pF	200pF	50pF

"O" OPTION ONLY

"T" OPTION ONLY

TOLERANCES UNLESS OTHERWISE SPECIFIED		UNHOLTZ + DICKIE CORP.	
RESISTORS	1%	SCALE	INCHES
CAPACITORS	5%	DRAWN BY	TU
IC'S	5%	APPROVED BY	
TITLE COMPONENT LAYOUT			
OSC-TF BUFFER-SERVO FILTER			
DATE	5-29-74	DRAWING NUMBER	FIGURE 5.7

12493



INPUT POWER SUPPLY

D22 PM
D22 PMH
D22 PMR

TOLERANCES UNLESS NOTED	UNHOLTZ-DICKIE CORP.
DECIMAL	±1 V
FRACTIONAL	±1 V
ANGULAR	±
DATE	10-4-74
TITLE	COMPONENT LAYOUT
DESCRIPTION	DUAL REG. POWER SUPPLY
FIGURE	5.10



Dr. Usher is presently engaged in signal conditioner development at Unholtz-Dickie Corp. He received the D. Eng. degree at Yale University in 1957 and subsequently has been engaged in university teaching, consulting in the field of underwater signal processing, and in research and development activities for a wide range of projects in the field of vibration testing and measurement. His published work includes a number of technical articles in the above fields. He is a former associate editor for the ASA, and is currently a member of IEEE, IES, and Sigma Xi.

INTRODUCTION

The fields of digital computer technology and signal-processing techniques have experienced a period of explosive growth during the past decade. The development of analog signal conditioning equipment during the same period has not been nearly so dramatic, but some recent developments, as well as extensions and improvements of older ideas, deserve discussion.

The following areas are covered in this paper:

- (1) Multipurpose signal conditioners for a variety of input transducers.
- (2) Differential charge amplifiers and applications with high-temperature accelerometers.
- (3) Automatic range control and remote range control.
- (4) Low-frequency, low-amplitude measurements.
- (5) Direct-coupled differential amplifiers and bridge conditioners.

The above topics, which are by no means exhaustive, are discussed from the standpoints of application areas, important features, and typical specifications. However, before this discussion is undertaken, typical features of most signal conditioners, and charge amplifiers in particular, are reviewed in the following section. This discussion for many readers will be largely tutorial.

1. TYPICAL FEATURES

General Design

Early multichannel signal conditioners used common power supplies, but modular instrumentation with individual power supplies now constitutes a great majority of acquisitions. Six or more modules fit in a rack adapter for system applications, but single units can also be used for portable labor-

atory measurements. Power transformers are usually electrically shielded.

Current instrument design utilizes balanced regulated power supplies with short-circuit protection and balanced circuit design employing integrated circuit operational amplifiers wherever possible. This is generally true even for AC coupled designs, because balanced circuit design decouples any possible power supply effects from the signal bus to a high degree, and thus prevents undesirable feedback effects through the power supplies. The balanced circuit design also minimizes switching transients and allows the overall circuit to have a minimum number of coupling capacitors, which reduces the cost of the instrument.

The charge amplifier has evolved to be the conditioner of choice for piezoelectric accelerometers and other capacitive transducers. The primary reason for this is that the overall conversion gain of the transducer-charge amplifier combination is virtually insensitive to the length of the cable between the transducer and conditioner. This is not the case when a voltage amplifier is the signal conditioner, since the overall gain becomes dependent on the loading capacitance of the interconnecting cable.

Low noise, wide frequency range and high slew rate are desirable features of all signal conditioners. For the charge amplifier, high input charge capacity without saturating the input charge converter is also highly desirable.

Noise

Noise specifications are generally given in terms of a component referred to the input plus a component referred to the output so that the conditioner can be evaluated for any gain condition. For the charge amplifier a representative specification might read:

.005 pC (picocoulombs) rms plus .0015 pC rms/1000 pF input capacitance RTI (referred to input) plus 1 mV rms RTO for a 2 Hz to 20 kHz bandwidth.

The detailed RTI specification is necessary because the equivalent input noise of the charge amplifier increases with transducer capacitance as well as cable capacitance. The signal detectability may easily be calculated once the noise specification is known. For instance, with an accelerometer having a sensitivity of 80 pC/g, and a capacitance of 1000 pF (Unholtz-Dickie Model 75D21) with a 30 foot cable (1000pF) the wideband acceleration noise RTI due to the charge amplifier is:

$$g_n = \frac{.005 + 2(.0015)pC}{80 (pC/g)} = 10^{-4} \text{ g rms}$$

Thus 10^{-3} g can easily be measured with a signal-to-noise ratio of 20 dB.

Wideband Characteristics

Wide frequency range implies uniform frequency response over the range but does not necessarily assure full output can be maintained over that range. The amplifier output should be able to slew fast enough to reproduce large high-frequency transients. Typical frequency response specifications are:

$\pm 5\%$ 2 Hz to 30 kHz, $\pm 1\%$ 10 Hz to 10 kHz

The charge amplifier output should generally be capable of providing 10V peak at 20 kHz which corresponds to an output slew rate of 1.25 V/ μ sec since:

$$\text{Slew Rate} = 2\pi f_{\text{upper}} V_{\text{peak}} \times 10^{-6} \text{ V}/\mu\text{sec}$$

The maximum input charge for a charge amplifier is determined by the characteristics of the input charge converter. A typical charge converter has a 1 mV/pC transfer ratio and 10 V peak output without saturating. Thus a charge of 10^4 pC may be handled at the input without saturating the input converter. Saturating the input converter can cause loss of signal due to long recovery time. For an accelerometer having a sensitivity of 10 pC/g, this corresponds to a peak acceleration of 1000 g. A typical slew rate for a charge converter is 6 V/ μ sec (10 V output at 100 kHz). For reference a simplified block diagram for a charge amplifier is shown in Fig. 1.

Transducer Sensitivity Normalization

It is desirable to have the rated value of the ranged output of a signal conditioner represent the same full-scale physical input values regardless of the transducer sensitivity or transfer ratio. A necessary feature to accomplish this is the gain-normalizing amplifier in Fig. 1. The gain

normalization function is usually accomplished by a multi-turn precision potentiometer which adjusts the feedback ratio of the gain-normalizing amplifier. The transducer sensitivity is set directly on the turns-reading dial of the potentiometer, which automatically provides a signal conditioner gain which is inversely related to the transducer sensitivity.

A typical charge amplifier is designed to accept transducer sensitivities from 1 pC/g to 100 pC/g in two 10:1 ranges. The significant digits of the sensitivity are set on a ten-turn locking dial. Rated output is typically provided for full scale inputs from 1g to 1000g, although extension of this range by 10:1 at either end is not uncommon.

Ground Signal Rejection

In many cases a ground loop can exist because the transducer case is attached directly to the metallic test structure and the test structure is connected electrically to the reference bus of the instrumentation. Refer to Fig. 2. In many cases there is a significant voltage which exists across this electrical connection because of long length, magnetic fields, and ground return currents. The resulting current through the shield of the transducer cable establishes an undesirable signal voltage, which is fed to the input converter through the capacitance of the cable and transducer. This input is amplified by the signal conditioner to produce a large undesirable output.

A simple remedy is, of course, to insulate the transducer case from the structure, but this may not be physically desirable or possible. An alternate solution which allows the direct connection of the transducer to the structure can be had by separating the reference for the input amplifiers and output amplifiers at "X" in Fig. 2 and feeding the signal on the input reference bus to a differential connection on the output amplifiers. This interrupts current I and prevents the ground signal voltage V from feed-

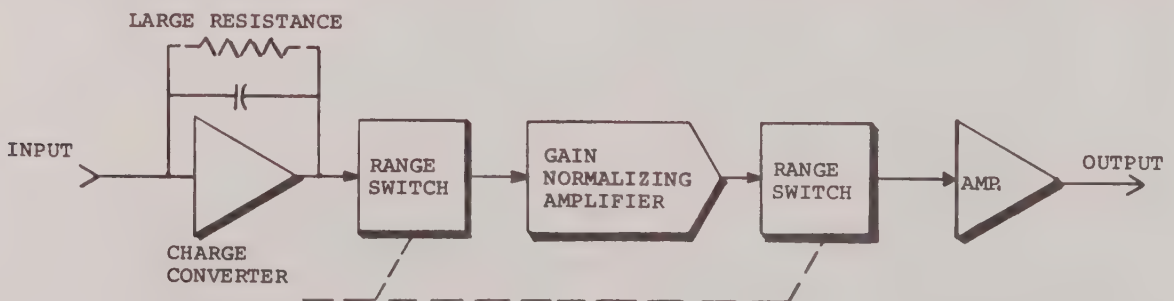


FIG. 1 SIMPLIFIED BLOCK DIAGRAM FOR CHARGE AMPLIFIER

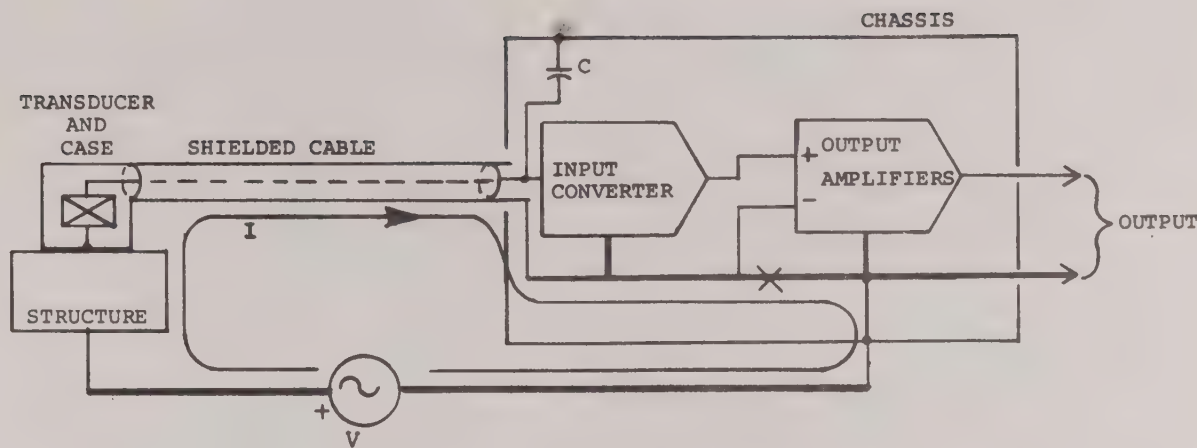


FIG. 2 EQUIVALENT CIRCUIT WITH TRANSDUCER GROUNDED AT TEST STRUCTURE

ing through the cable capacitance. Care must be taken in guarding the input converter so that the capacitance C from chassis to input is minimized. Rejection of the input ground signal for charge amplifiers is typically better than 50-60 dB.

A two-position switch is usually provided in most single-ended conditioners to accommodate either isolated or grounded transducer cases.

Remote Preamplifiers

Excessively long cables from the transducer have several disadvantages:

- (1) The signal-to-noise ratio decreases with length (note the noise specification for charge amplifiers).
- (2) For capacitive transducers, triboelectric noise can be a problem, even with treated cables.
- (3) Low-noise cables are comparatively expensive, and some commonly-used varieties are not particularly resistant to abuse.

A remote preamplifier, used instead of the internal charge converter, removes most of these objections because it can be located close to the transducer. The cable between the preamplifier and the conditioner can then be an inexpensive, sturdy coaxial variety in which the center conductor not only carries the signal voltage but also the operating voltage and current for the preamplifier. Triboelectric noise is not a problem because of the low source impedance of the output of the remote preamplifier.

Provision for using either the internal converter or a remote preamplifier by means of a switch has been a desirable feature for signal conditioners. The preamplifier power supply is included in the signal conditioner.

Miscellaneous Features

Many signal conditioners provide for a variety of low-pass filters, since there may be no need to measure over the entire frequency band of the conditioner, and maximum signal-to-noise ratio is desired. High-pass filtering is discussed in a later section.

Some means for providing full-scale output calibration and a test of the cable and transducer integrity is often provided.

Optional features on signal conditioners can also include:

- (1) Constant sensitivity output (i.e. 10 mV/g) for control of vibration tests.
- (2) High-current drivers for galvanometer recording and driving long lines.
- (3) Meter indication.
- (4) Logarithmic (DC) conversion of the output for plotting purposes.

2. MULTIPURPOSE SIGNAL CONDITIONERS

Several years ago facilities which had cause to work with a large variety of transducers, such as piezoelectric accelerometers, servo accelerometers, piezoresistive accelerometers, strain gages, thermocouples, etc., required several different instruments to accommodate the measurement tasks. This proved to be expensive, especially if the individual utilization time of the separate instrument happened to be low. The solutions to this problem which have evolved are based on the observation that some portion of the electronics for the different instruments is quite similar.

One solution has been to provide an instrument main frame with the necessary power supplies, input connectors and output connectors. Plug-in cards with attached front panels and supplementary controls provide the condition-

ing requirements for each separate application, and include a charge amplifier, a bridge conditioner with amplification, a carrier amplifier and other bridge conditioners.

Another recent solution has been to provide an instrument main frame with the necessary power supplies, direct-coupled post-amplifier, meter, gain controls, input connectors and output connectors. Separate plug-in chassis provide the necessary conditioning for capacitive transducers (charge converter), servo accelerometers, and bridges with 1, 2, or 4 active arms. The separate plug-in chassis also contain front panel controls for gain normalization and calibration.

A third solution, which differs somewhat from the so-called "Universal Signal Conditioners" described above, provides a single instrument (U-D Model D22PMR), shown in Fig. 3, with front-panel switching for the following applications:

- (1) Charge amplifier for piezoelectric accelerometers, force gages, and pressure transducers.
- (2) High input-impedance voltage amplifier for general applications.
- (3) Direct inputs from single strain gages for dynamic strain measurement.
- (4) Inputs from remote preamplifiers.

All four applications above are provided by changing connections to the input converter or by rerouting the signal past the input converter (application 4). In addition, the strain-gage mode of operation provides the selection of several accurately-determined values of constant-current excitation for the strain-gage. The current is applied through the center conductor of the connecting cable.

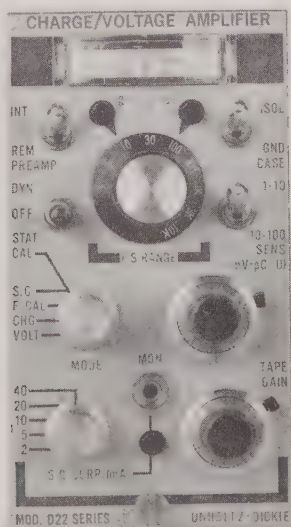


FIG. 3 MODEL D22PMR
MULTIPURPOSE SIGNAL CONDITIONER

The feature of sensitivity normalization is preserved for all modes of operation. The explanation of how this is accomplished for the strain-gage mode follows. The gage factor F is defined by:

$$F = (\Delta R/R) / (\Delta L/L) \quad (1)$$

where $\Delta L/L$ is strain and ΔR is the change of resistance for gage resistance R . The change in output voltage for the gage with constant current excitation is

$$\Delta V = \Delta RI \quad (2)$$

The gage transfer ratio or sensitivity S is defined by

$$S = \Delta V / (\Delta L/L) \quad (3)$$

Substituting (1) and (2) in (3) yields

$$S = FRI \quad \begin{array}{l} \text{millivolts/millistrain} \\ \text{or mV/1000 microstrain} \end{array} \quad (4)$$

Since F and R are accurately determined by the gage manufacturer and I is accurately ($\pm 1\%$) determined by a switch setting on the conditioner, a sensitivity is easily calculated and set on the gain-normalization dial.

For example, if $F = 2.00$, $R = 120$ ohms, and $I = 40$ ma, we have $S = (2)(120)(.040)$ or 9.60 mV/1000 μ e.

Transducer sensitivities from 1 to 100 mV/engineering unit can be accommodated. (Here one engineering unit (eu) is 1000 μ e, 1 g, 1 psi, etc.) Ranging is provided for full-scale inputs from 1 to 1000 eu for the charge or voltage mode, and from 10 to 10000 μ e in the strain-gage mode. Noise in the strain-gage mode is typically less than 0.5 μ e rms RTI for the numerical example above.

A multivibrator can also be activated to dynamically shunt a preselected resistance value across the strain gage. The peak-to-peak value of the simulated square wave strain can easily be calculated and used as a check on the calibration of the instrument.

The third multipurpose signal-conditioner described above does not provide the exceptionally wide application range that the "Universal Signal Conditioners" provide, particularly for bridge measurements, but it does provide a means for making the most commonly used dynamic measurements. Also, only one instrument is required rather than one main frame and several plug-in panels.

3. DIFFERENTIAL CHARGE AMPLIFIERS

High-Temperature Measurement

Applications for monitoring vibrations of such sources as jet engines, nuclear power plant components, and automobile mufflers have required high-temperature accelerometers. Accelerometers have been developed for measurements at temperatures as high as 1400°F, but the shunt resistance of such accelerometers decreases to the vicinity of

10 kilohms at this temperature. Typically, the shunt resistance of high-temperature accelerometers decreases by a factor of 5-10 for a 200°F increase in temperature above temperatures of 700°F.

Some high-temperature accelerometers have also been constructed so that the crystal is isolated from the case, whereas the conventional lower-temperature accelerometer is constructed with one side of the crystal common to the case. The isolated construction requires a balanced two-wire signal connection with the shield preferably connected to the case. The balanced configuration is apparently an outgrowth of the situation that electrostatic shielding is often not very good in certain areas for high-temperature vibration-monitoring applications. The balanced line offers the best possibility for power frequency harmonic rejection.

High-temperature accelerometers have thus caused the following design changes and emphases in charge amplifiers:

- (1) The input charge converters have been redesigned so that they will not saturate or block due to low resistances across the input.
- (2) The noise due to the input charge converter at low frequencies must be extremely low, since this noise is emphasized by decreasing input shunt resistance.
- (3) High-pass filters have been added to charge amplifiers to sharply cut off the spectrum below the minimum signal frequency to maximize the signal-to-noise ratio.

- (4) Differential charge converters have been designed to accommodate the isolated-crystal accelerometers.

Noise Characteristics

The relative noise spectrum (RTI) for a differential charge amplifier with a very large value of shunt resistance is shown in Curve A of Fig. 4. Note that the spectrum rises slightly at low frequencies, which is characteristic of the high-quality FET selected for the input device in the charge converter.

When a relatively low value of shunt resistance (50 kilohms) is placed across the input of the charge converter, the closed-loop forward gain of the device is not markedly affected, but the loop-gain of the charge converter is markedly decreased at the lower frequencies due to the low value of R_S . The effect is to cause the noise spectrum to increase at 1/f rate above curve (A) as frequency decreases. The frequency at which the spectrum begins to deviate from curve (A) is determined by:

$$f_C = 1/(2\pi R_S C_f) \quad (5)$$

Where R_S is the shunt resistance and C_f is the feedback capacitance of the charge converter. For $R_S = 50 \text{ K}\Omega$, $C_f = 1000 \text{ pF}$, $f_C = 3180 \text{ Hz}$. Curve (B) in Fig. 4 shows the effect described.

Curve (B) also shows the effect of a three-pole Butterworth high-pass filter (-3 dB at 10 Hz) placed after the charge converter. The decrease in effective noise RTI below 10 Hz is due to this filter. Numerical integration of the square of Curves (A) and (B) from 1 Hz to 20 kHz reveals that the rms value of the wideband noise for Curve (B) is approximately 10 times that for curve (A).

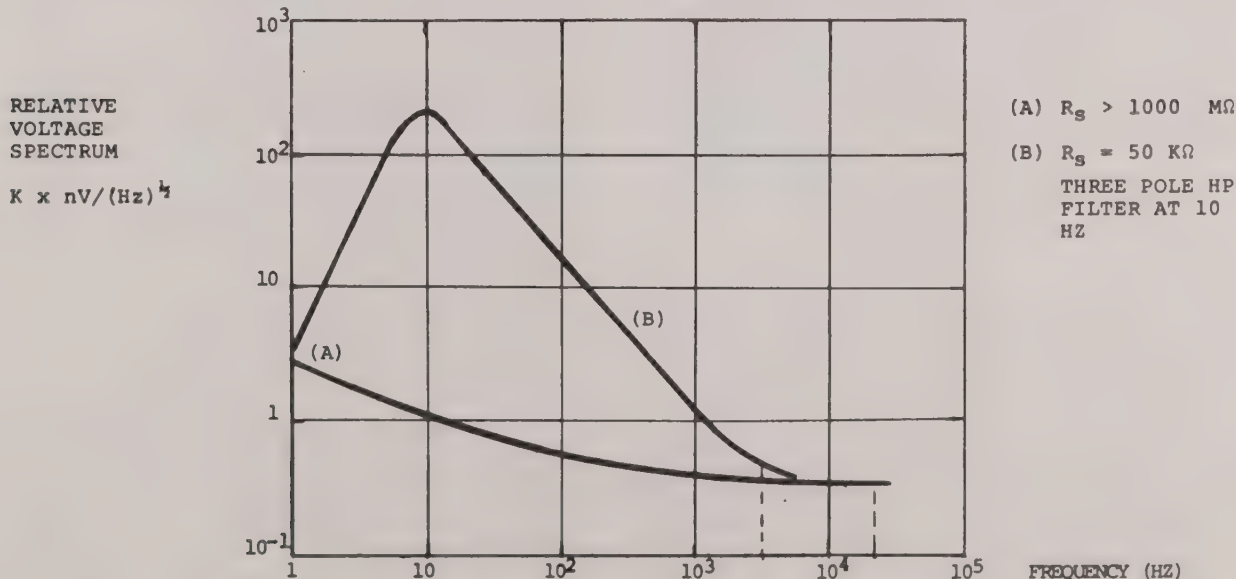


FIG. 4 RELATIVE NOISE SPECTRA FOR CHARGE CONVERTER WITH SHUNT RESISTANCE

A typical specification for the noise under the conditions for curve (B) is a maximum of .05 pC rms (U-D Model D22PMH). If the cut-off frequency for the high-pass filter can be increased for any reason, the low-frequency noise that is seen under conditions of low shunt resistance can be decreased. It is interesting to note that shunt capacitance at the input to the charge converter also increases the noise (RTI) of the charge converter, but in this case the spectral level is increased uniformly at all frequencies.

Differential Charge Converter

The differential charge converter is schematically shown in Fig. 5, along with other input parameters. It can be shown that the output voltage V_o is:

$$V_o = -\frac{Q}{C_f} + \frac{V_2 C_2 (C_1 + C_3 + C_f) - V_1 C_1 (C_2 + C_4 + C_f)}{C_f (C_1 + C_2 + C_3 + C_4 + 2C_f)} \quad (6)$$

In Eq. 6 the first term represents the desired output from the accelerometer and the second and third terms represent the undesirable outputs from the power frequency (hum) sources V_1 and V_2 . The capacitances C_1 and C_2 represent stray pickup capacitances for the power frequency voltages and C_3 and C_4 represent line-to-shield capacitances.

The signal-frequency gain of the charge converter is not dependent on the relative values of C_3 and C_4 if the gain of the differential amplifier is very high. However, the ability of the charge converter to reject power frequency signals due to the pickup through the stray capacitances C_1 and C_2 is critically dependent upon the external circuit parameters. In general, the second and third terms of Eq. (6) come close to cancelling each other only if the lines are well-balanced ($C_3 \approx C_4$), the stray capacitances are very nearly equal ($C_1 \approx C_2$) and the hum sources are equal or are the same source ($V_1 \approx V_2$). The analysis leading to Eq. (6) is based on the assumption that the differential amplifier in Fig. 5 itself has perfect common mode rejection.

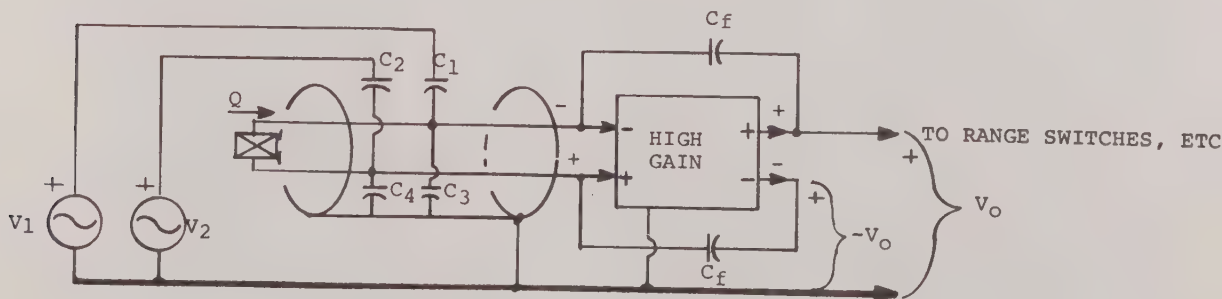


FIG. 5 EQUIVALENT CIRCUIT FOR DIFFERENTIAL CHARGE CONVERTER

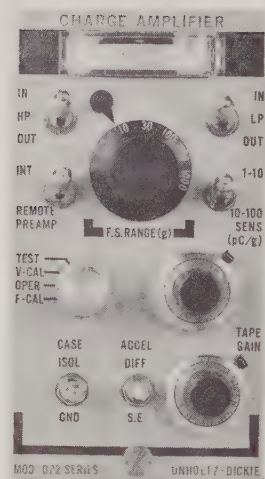


FIG. 6 MODEL D22PMH DIFFERENTIAL CHARGE AMPLIFIER

Fig. 6 shows the front panel for the U-D Model D22PMH with front panel switches to control high and low-pass filtering, case isolation or grounding, and differential or single-ended charge conversion.

4. AUTOMATIC AND REMOTE RANGE CONTROL

The development of new aircraft, spacecraft and other large structures has required large instrument arrays for simultaneously monitoring motions and stresses on all parts of the test structure. Manual control of large instrument arrays is an almost impossible task for such situations.

Instruments have been developed for which the functions of full scale ranging, calibration, and transducer sensitivity normalization are completely controlled by digital means. However, it is the feeling of this author that such instruments require a large number of control lines and are wasteful of computer memory. Their utility as single-channel portable monitors is also questionable.

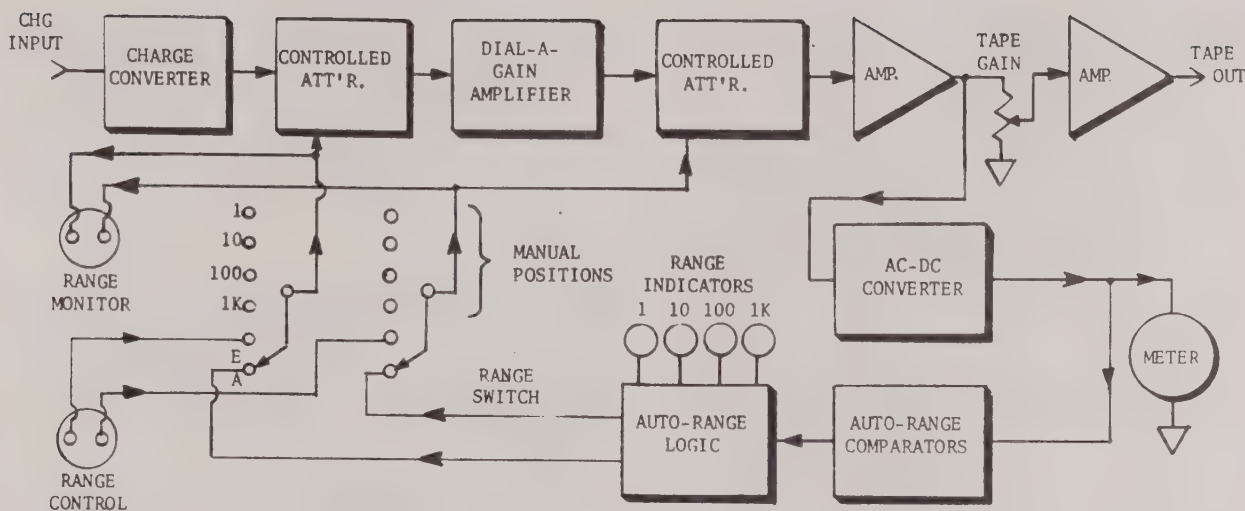


FIG. 7 BLOCK DIAGRAM MODEL D22PMA
AUTORANGING CHARGE AMPLIFIER

Fig. 7 portrays the block diagram of an instrument (U-D Model D22PMA) that serves equally well in large arrays or singly as a portable monitor. The availability of CMOS switches coupled with simple TTL logic, allows the full-scale range to be manually controlled, externally controlled by only two lines, or automatically controlled to the best of four different values. Transducer sensitivity normalization is accomplished by the conventional front-panel technique, and calibration (not shown) is accomplished by relay control. Two-line (binary signal) range monitoring is available for the manual, external, or automatic modes of range control.

Most FM recorders have a 45-50 dB dynamic range. Two-line control or monitoring provides four ranges at 20 dB intervals. This allows an 80 dB range of signals to be recorded, with the minimum recorded signal 25-30 dB above the noise floor of the recorder.

Storage of transducer sensitivity information in a computer for the purpose of compensating data amplitudes appropriately or for the purpose of digitally controlling a compensating circuit in the instrumentation channel is a waste of computer memory or a gross waste of control lines. Normalizing instrument gain to 1% accuracy for a 100:1 range of transducer sensitivities can require from 7 to 13 lines per channel, depending on the method used.

For large arrays, it is much simpler to use accelerometers with closely adjusted sensitivities. A typical example is the U-D

Model 10B10 with a charge sensitivity of 10 pC/g $\pm 1\%$. The sensitivity settings can then be made and locked on all instruments to identical values. Replacement or interchange can be done without affecting system accuracy, and without causing possible errors due to system parameters failing to be reprogrammed or reset.

For each array only one additional line is required to trigger the relay power supply and cause simultaneous full-scale calibration for all channels in the array. For large arrays the number of external range control and/or monitoring lines can be reduced further, because one instrument can be connected to control the full-scale range of several others in a master-slave arrangement.

5. LOW FREQUENCY, LOW AMPLITUDE MEASUREMENTS

Modal testing of large structures often requires the detection of low-frequency mode shapes at necessarily low acceleration values. This also means that the noise level of the transducer and signal conditioning device must be exceptionally low.

A new solution to this problem (U-D Model 500PA) involves close coupling a high-sensitivity piezoelectric accelerometer and an exceptionally low-noise voltage amplifier in a single housing. The accelerometers are carefully screened for minimum sensitivity to thermal transients, and are of shear design to assure insensitivity to base bending and case effects. The voltage

amplifiers have exceptionally low noise and exceptionally low input leakage current to allow flat frequency response to 0.1 Hz (3dB down at .01 to .02 Hz).

The overall sensitivity of the active transducer is from 0.5 to 1.0 V/g and can easily be adjusted to a tolerance of $\pm 1\%$. The four-wire connection to the transducer supplies positive and negative power supplies, signal output, and signal reference. Since the output impedance of the preamplifier is low, an inexpensive cable can be used which is abuse-resistant, and triboelectric noise is negligible.

The signal conditioner can be a relatively inexpensive device which provides the power supply voltages, different full scale ranges, and low-pass filtering. Full-scale ranges of .01g to 10g are typical with a wideband equivalent input noise of 3×10^{-5} g rms from 1 Hz to 2 kHz. The frequency response of the conditioner must also be flat from 0.1 Hz to the desired upper frequency.

6. DIRECT-COUPLED DIFFERENTIAL AMPLIFIERS

Direct-coupled differential amplifiers find wide application for use with thermocouples, piezoresistive accelerometers, and strain gage bridges. Bridge transducers are used to provide means for measuring accurate zero frequency response as well as for simulating variables that are not physically measurable with a single strain gage, such as shear strain.

Features

A direct-coupled differential amplifier that is designed primarily for bridge transducers should have several additional features in addition to meeting typical specifications for a differential amplifier. These features include:

- (1) Internal provision for bridge completion resistors so that bridges with 1, 2 or 4 active arms may be used. Preferably the bridge completion resistors are on a plug-in card.
- (2) Inclusion of an accurate, highly-regulated low-noise constant-voltage power supply for excitation of the bridge. Several switch-selected values of voltage are desirable. Occasionally accurate constant-current excitation is requested.
- (3) Additional connections for remote voltage sensing so that the accurate power supply voltage is maintained at the bridge to eliminate long-line effects.
- (4) Additional connections for single shunt calibration. The total number of connector terminals to the bridge can be at least 8, plus shield to accommodate the four bridge connections, remote voltage sensing and calibration connections.

- (5) Provision for user - selection of the shunt calibration resistors.
- (6) A means for normalizing the instrument gain with respect to the transfer ratio or sensitivity of the bridge. This allows quick calibration of the instrument in terms of the full scale value (in eu) shown on the range switch. A technique for this is indicated later in this section.

Important Specifications

Important specifications for the differential amplifier include input impedance, pump-out current, zero drift, zero stability, noise, common mode characteristics, and frequency response. These specifications are discussed in some detail in the following paragraphs:

- (1) The input impedance can vary from 10^6 to 10^9 ohms typically. Generally, the higher the input impedance, the lower the pump-out current, and the better the common mode rejection (CMR) for unbalanced source impedances.
- (2) The pump-out current is direct-current emanating from the input terminals. It can vary from less than 1 nanoampere (nA) to 100 nA. The pump-out current determines the amount of internal bridge balance correction necessary for unbalanced source impedances. The differential temperature coefficient of pump-out current can affect zero drift for high bridge resistances.
- (3) Zero drift is an extremely important specification which is usually given in terms of voltage drift per degree temperature change with two components: one RTI and the other RTO. Sometimes the drift is specified in terms of percent of full-scale deviation per degree temperature change, but this can always be converted to the voltage specification. Typical specifications vary from:
 $0.1 \mu\text{V}/^\circ\text{C RTI} \pm 20 \mu\text{V}/^\circ\text{C RTO}$
for chopper stabilized amplifiers to:
 $10 \mu\text{V}/^\circ\text{C RTI} \pm 1 \text{ mV}/^\circ\text{C RTO}$
for less expensive amplifiers using close thermal compensation. It is assumed that the maximum gain of most bridge conditioners is at least 1000.
- (4) Zero stability gives the long-term stability of the amplifier over typically an 8 or 24 hour period, at constant ambient temperature. Typical specifications vary from:
 $\pm 1 \mu\text{V RTI} \pm 100 \mu\text{V RTO}$ over 200 hours
for chopper-stabilized amplifiers to:
 $\pm 40 \mu\text{V RTI} \pm 10 \text{ mV RTO}$ for 24 hours
for less expensive amplifiers using monolithic input stages.
- (5) The noise specification is usually given in at least two parts to account for the

increased spectral levels at very low frequencies. In a sense, the long-term stability specification can be considered to be a very low frequency noise specification. Typical specifications vary from:

3 μV rms for 100 kHz bandwidth and 2 μV peak-to-peak for 10 Hz bandwidth for chopper-stabilized amplifiers. (Both RTI).

5 μV rms for 10 Hz to 10 kHz band and 10 μV peak-to-peak for 0.1 to 10 Hz bandwidth for monolithic input devices (both RTI)

The component RTO varies from 1 mV to 6 mV rms depending on the upper frequency limit (usually 10 kHz to 100 kHz)

It is necessary to note that the zero stability specification must be larger than the low frequency noise specification above to be meaningful. Also, an extremely low specification of zero drift is not very useful for an instrument which does not have correspondingly good specifications for zero stability and noise. In other words, a zero drift of 0.1 $\mu\text{V}/^\circ\text{C}$ RTI would not be very useful with an instrument with 10 μV p-p low frequency noise.

- (6) The specification of common-mode characteristics usually has two major parts: the rejection-ratio (CMRR) and the maximum common-mode voltage (CMV). The CMRR is usually specified at maximum gain. Typical values of CMRR vary from 80 dB to 130 dB over the frequency range from 0 to 60 Hz. The maximum common-mode voltage varies from $\pm 10\text{V}$ to 350V.

The specification is necessary to insure good rejection of power frequency voltages induced in the cable connecting the bridge to the conditioner, as well as the large static operating voltages for the bridge. The common-mode voltage should be at least as large as the maximum bridge supply voltage.

Gain Normalization

An accurate internal power supply for exciting the bridge is an important feature in order to provide gain normalization. It allows the bridge sensitivity to be quickly calculated. Consider the following example.

The output voltage ΔV due to a change in resistance ΔR of a single-active-arm bridge with element resistance R and excitation voltage V can easily be shown to be:

$$\Delta V = \frac{\Delta R}{4R} V \quad (7)$$

The gage factor and bridge sensitivity are defined in Eqs (1) and (3), which are repeated below:

$$F = (\Delta R/R)/(\Delta L/L) \quad (1)$$

$$S = \Delta V/(\Delta L/L) \text{ mV}/1000 \mu\epsilon \quad (3)$$

Substitution of (7) and (1) into (3) yields:

$$S = \frac{FV}{4} \quad (8)$$

With more than one active arm, and identical gages:

$$S = \frac{(\text{active arms})FV}{4}$$

Calculation of bridge sensitivity is extremely simple and accurate, because both F and V are known accurately.

The sensitivity normalization circuit can follow the differential input circuit in the bridge conditioner. A ten turn locking dial and a two position range switch can easily provide normalization over a 100:1 range of input sensitivities.

CONCLUSION

This paper was prepared as a prelude to the revision of ANSI Standard S2.4-1960 by subcommittee S2-64 of the ANSI Committee on Mechanical Shock and Vibration.

REFERENCES

- "Specifying the Characteristics of Auxiliary Equipment for Shock and Vibration Measurements" ANSI Standard S2.4-1960, American Standards Association, New York, N.Y. (1960)
- "Methods for Specifying the Characteristics of Auxiliary Equipment for Shock and Vibration Measurement" International Electrotechnical Commission Publication 222, Geneva, Switzerland (1966).

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CORPORATION**



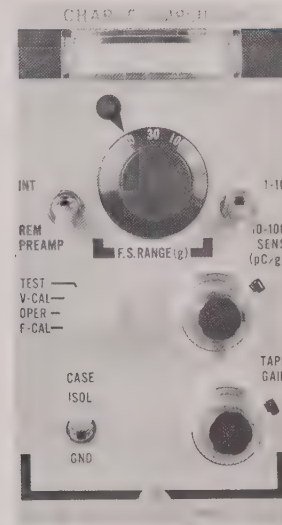
**VIBRATION TEST
EQUIPMENT**

The "Basic"

MODEL D22PM CHARGE AMPLIFIER

A General-Purpose Laboratory Instrument

- EXTREMELY LOW-NOISE OPERATION
- DIAL-A-GAIN SENSITIVITY NORMALIZATION
- CALIBRATED FULL-SCALE OUTPUT
- OPERATION WITH REMOTE PREAMPLIFIERS
- DIFFERENTIAL REJECTION OF GROUND SIGNALS
- PLUG-IN 3-POLE FILTER
- LOW POWER CONSUMPTION
- THREE CALIBRATION MODES
- INSENSITIVE TO EXTERNAL VIBRATION
- INDIVIDUAL SHIELDED POWER SUPPLIES
- WIDE VARIETY OF OPTIONS



The Model D22PM is the successor to the Model D11 line of instruments. The D22PM features plug-in card construction, extensive use of integrated circuits and rugged construction. Independent power supplies and shielded transformers are used so that individual operation is possible, grounding problems are minimized in large installations, and good power line isolation is provided.

In addition, separable references are provided for the input and output circuits so that an internal differential circuit can remove common-mode ground voltages caused by having the transducer case grounded at the point of measurement.

The Dial-A-Gain sensitivity normalization, originated by Unholtz-Dickie, allows the various outputs to be normalized for piezoelectric transducer sensitivities ranging from 0.5 to 100 pC/unit.

Being a charge amplifier, the gain of the D22PM is, of course, insensitive to input cable length.

NOISE

Extremely low output noise has been attained by careful selection of the input FET for the charge converter. Careful shielding, highly regulated power supplies and balanced circuitry keeps power frequency contamination extremely small. The built-in 3-pole low-pass filter can be selected to optimize the signal-to-noise ratio by proper knowledge of the expected signal spectrum.

Using the D22PM and the U-D Model 75D21 Accelerometer, with a relatively short low-noise cable, it is possible to achieve a typical noise level of 50×10^{-6} g rms over a 10 kHz frequency range. This means that acceleration levels less than .001 g may be accurately measured.

OUTPUTS

The standard tape output is calibrated to give exactly 10 V peak for full scale inputs for full clockwise rotation (10 turns) of the TAPE GAIN potentiometer. The locking dial accurately determines full scale output for other settings. The 1.24 inch scale edge-reading meter is calibrated in percent of full scale. Options include servo control (S) at 10 mV/g, a high-current driver for long lines or galvanometers (C or G), linear DC output (F), and logarithmic DC output (L).

RANGES

The maximum instrument gain, for a full scale range setting of 1 g and an input sensitivity of 1 pC/g, is 10 V/pC. Standard manual ranging provides seven full scale ranges from 1 to 1000 g in 1, 3, 10 steps, for input sensitivities from 1 to 100 pC/g.

RANGE ±1% OF RANGE *

SENS. DIAL ±1% OF SETTING *

The high gain option (-3) gives a maximum gain of 100 V/pC and nine ranges from 0.1 to 1000 g in 1, 3, 10 steps.

SENS DIAL RANGING ±1% *

The external range control (E) and automatic-ranging (A) options described extensively in another bulletin provide four full-scale ranges: 1, 10, 100, and 1000 g. Two-line range control is possible for the E option and the best range is automatically selected for the A option. The E option also allows manual range control and the A option includes all the E option features.

FILTERS

A three-pole low-pass Butterworth filter is contained on a sub-plug-in board within the instrument. The instrument may be operated with the filter plug-in removed if desired. Other filter frequencies are easily and economically supplied.

CALIBRATION

The D22PM provides three calibration/checking Modes: F-CAL, V-CAL, and TEST. The F-CAL mode provides full scale output for 100 mV peak input regardless of range and sensitivity settings. The V-CAL mode provides an output dependent on all front-panel settings. The TEST mode inserts the calibration signal in series with the accelerometer cable shield. An open or shorted line is easily detected.

REMOTE PREAMPLIFIER

Remote voltage preamplifiers or charge preamplifiers such as the U-D Model 11PA-2 or Model 22CA-2, are accommodated by changing a front panel switch from INT. to REM. This allows the internal charge converter to be bypassed and means that standard low-cost coaxial cable may be used between the measurement site and the instrument. Triboelectric noise for long-line measurement is also avoided.

SPECIFICATIONS MODEL D22PM

1. GENERAL

- 1.1 Separate, isolated power supplies are provided in each channel
- 1.2 All power and signal connections are made at separate rear mounted connectors.
- 1.3 Each channel is totally enclosed so that it can be used with equal convenience as a bench mounted or as a rack mounted instrument.

2. INPUT CHARACTERISTICS

- 2.1 Charge input - direct connection to any piezoelectric transducer with 10 Megohms, or greater, shunt resistance.
- 2.2 Remote Preamp Input - two-wire connection to remote charge type or voltage type preamp that can be added to the system at anytime. The Preamp connector supplies the required bias voltage/current to the remote preamp.
- 2.3 Gain Change with Source Capacitance in Charge Mode (INT.) - A source capacitance of 50,000 pF shall cause less than 0.1% gain change for transducers having a sensitivity between 1 and 100 pC/unit.
- 2.4 Gain Change with Remote Preamp Mode (REM. PRE-AMP) - all instrument gain controls and range switches shall apply when operation is converted to the remote preamp mode. The basic instrument accuracy shall change by less than $\pm 1\%$. Up to 2,000 feet of RG58/U coaxial cable shall cause a gain change of less than 1% when connected between the instrument and the remote preamp.
- 2.5 Maximum Input in Charge Mode (INT.)
 $\pm 15,000$ pC (1 to 10 pC/g.) $\pm 150,000$ pC (10 to 100 pC/g.)

3. OUTPUT

- 3.1 Tape Driver - Calibrated ± 10 V peak at full scale condition into 1 K load. Ten turn locking potentiometer allows precision adjustment between 0 to 10 V. Output impedance less than 50 ohms direct-coupled.
- 3.2 Standard Meter - 1.24 inch scale meter calibrated in percent of full scale. Accuracy $\pm 2\%$ of full scale; average detector provided. Dual scale is available upon request.
- 3.3 Large Meter (Option "-8") - 2.5 inch scale length with 2 scales calibrated 0 - 10 and 0 - 3. Increases front panel height to 8-3/4 inches.
- 3.4 Servo Control (Option "S") - Output normalized to 10 mV pk/g pk, not dependent upon range switch position. No signal clipping occurs at the servo output at levels less than 100 g on any full scale range, and operates to 1000 g without clipping when placed on that range.
- 3.5 Galvanometer Driver (Option "G") - A high current amplifier provides a separate independent output with a current capacity of ± 100 mA. Ten turn locking potentiometer allows precision adjustments between 0 and 10 V. Output impedance less than 1 ohm direct-coupled.
- 3.6 Log DC Output (Option L) - A DC output proportional to the logarithm of the input amplitude. The calibration constant is ± 1.0 V/decade and an output of 0 V DC is provided at full scale.
- 3.7 Velocity Integrator (Option I) - Output normalized to 100 ± 10 mV-sec/in, not dependent on range switch position.

4. FREQUENCY RESPONSE

- 4.1 Low Pass Filter "Plug-In" Removed
 $\pm 1\%$ 10 Hz to 10 kHz $\pm 5\%$ 2 Hz to 30 kHz
- 4.2 Low Pass Filter "Plug-in" Installed - Plug-in component card supplied with unit is 3 pole maximally-flat Butterworth design. Filter frequency f_0 can be supplied in 1, 2, 5, 10 sequence from 50 Hz to 10 kHz. Response at f_0 is rated $\pm 2\%$ and at $2 f_0$ is -3 dB ± 1 dB, with 18 dB/oct. attenuation rate.

5. RANGE SWITCHING

- 5.1 Standard - 1 to 1 K g full scale in 1-3-10 sequence for 1-100 pC/unit.
- 5.2 Option 3 - .1 to 1 K g full scale for 1-100 pC/unit in 1-3-10 sequence.
- 5.3 Option E - 1, 10, 100, 1000 g full scale controlled by front panel switch or by external 2-line binary control compatible with TTL logic. Logic 1 can be as high as +15 V.

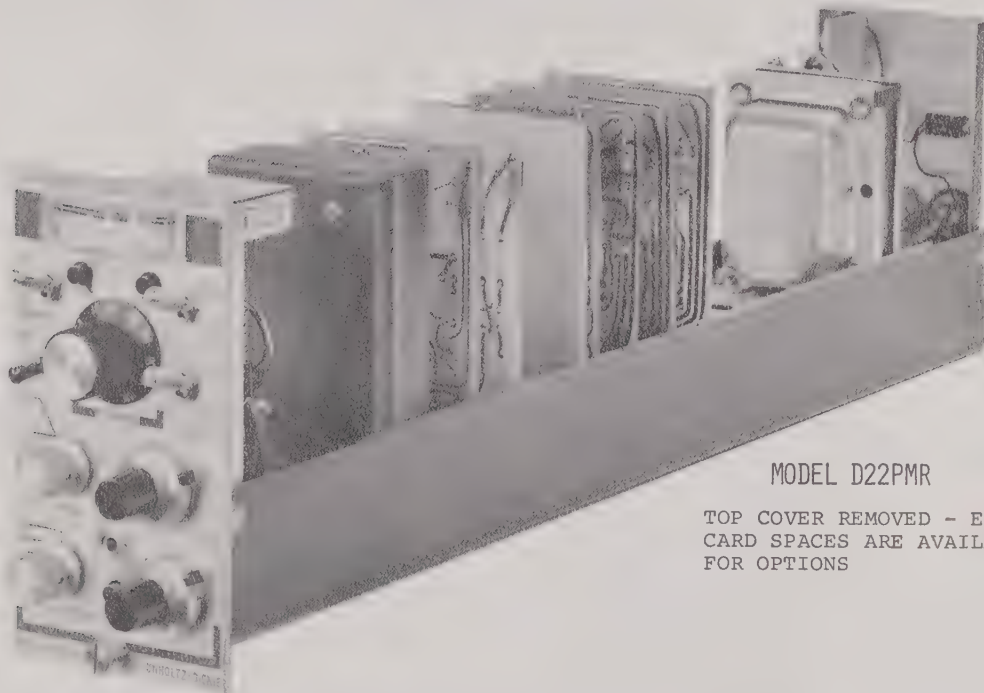
6. MAXIMUM NOISE (RTI-referred to input; RTO-referred to output) All statements refer to 10 kHz low-pass filter, and 10 Megohm input resistance or greater.
- 6.1 Standard Range Option - .005 pC rms plus .0015 pC rms/1000 pF source capacitance RTI for 1-10 pC/unit and .05 pC rms plus .0015 pC rms/1000 pF source capacitance for 10-100 pC/unit RTI plus 1 mV rms RTO.
- 6.2 Range Option 3 - .005 pC rms plus .0015 pC rms/1000 pF source capacitance RTI for 1-10 pC/unit and .05 pC rms plus .0015 pC rms/1000 pF RTI for 10-100 pC/unit. plus 5 mV rms RTO.
7. CALIBRATION MODES
- 7.1 F-CAL - provides full-scale output for 100 mV peak input independent of full scale range or sensitivity setting.
- 7.2 V-CAL - connects calibration signal through precision 1000 pF $\pm 1\%$ capacitor directly to charge amplifier input providing 1 pC/mV conversion.
- 7.3 TEST - connects calibration signal in series with shield of input cable.
- 7.4 OPER - calibration signal disconnected for normal operation.
- 7.5 Internal Oscillator (Option O) - provides calibration signal of 100 mV peak $\pm 1\%$ at 100 Hz. One oscillator can supply a total of six channels with patch cables supplied.
8. GROUND SIGNAL REJECTION - This input ground/output ground isolation feature allows the transducer case to be grounded at the test site without introduction of output due to ground loops.
- 8.1 The output voltages normally created by ground loops due to grounded transducer cases are rejected by at least 60 dB at maximum instrument gain from 5 Hz to 1 kHz.
- 8.2 The front panel range switch lamp verifies the correct position of the ISOL-GND front panel switch.
9. HARMONIC DISTORTION less than 0.5% and amplitude linearity is $\pm 1\%$ of best straight line.
10. POWER - Individual power supplies in each module; double-shielded power transformer; 100-130 V AC or 200/260 V AC; 50/60 Hz; 5 VA consumption
11. FRONT PANEL CONTROLS
- 11.1 Full Scale Range Switch
- 11.2 Mode Switch-Test; V-Cal; Oper; F-Cal
- 11.3 Sensitivity Dial (10 Turn locking)
- 11.4 Sensitivity Range Switch 1-10, 10-100
- 11.5 Case Switch - Isol; Gnd. (Range Pilot)
- 11.6 Preamplifier Switch - Remote; Internal
- 11.7 Tape Gain Dial (10-turn locking)
12. PHYSICAL
- 12.1 Single Module Standard - 2.8 W x 5.25 H x 19 D - requires Model 22RA Rack Adapter for multichannel mounting of up to six channels.
Rack Adapter 22R: 19 W x 5.25 H x 21 D (6 modules)
- 12.2 Single Module "-8" Option - 2.8 W x 8.75 H x 19 D - requires Model 22RA-8 Rack Adapter for multichannel mounting of up to six channels.
- 12.3 Connectors are all coaxial BNC except for:
Oscillator-Patch-miniature phone jacks - mating connector supplied
- 12.4 Weight: Single module - nominal 6 pounds
- 12.5 Operating Temperature: 40°F to 125°F

4.44°C to 38.34°C
51.66°C

UNHOLTZ-DICKIE CORPORATION

vibration generation systems and measurement instruments

MODEL D22 SERIES OPTION DESCRIPTIONS



MODEL D22PMR

TOP COVER REMOVED - EMPTY
CARD SPACES ARE AVAILABLE
FOR OPTIONS

The printed-circuit plug-in card construction of the D22 Series enhances the versatility of the instrument line. A large number of options are available. A definite description of each option is given below, except for the External Range Control (E) and Autoranger (A) options which are found on a separate bulletin D22-EA-74. For specific option availability with the D22PM "Basic", D22PMH "Red Hot", and the D22PMR "Multi", consult the table in Bulletin D22-74.

SERVO (S)

The servo (acceleration) output has a 10 mV/g sensitivity which is independent of the range switch setting. Output impedance is less than 50 ohms, and a maximum of $\pm 10\text{V}$ at $\pm 10\text{ mA}$ is available on at least one range with never less than $\pm 1\text{V}$ available on all ranges (100 g). Standard frequency response is flat within $\pm 2\%$ to 5 kHz and 3 dB down at 10 kHz unless otherwise specified.

LOGARITHMIC DC OUTPUT (L)

A sensitivity of $\pm 1\text{V}$ per 20 dB of input change is provided, and 0V DC output corresponds to full scale sinusoidal inputs. A dynamic range of 60 dB is supplied with a stability and accuracy of $\pm 0.2\text{ dB}$ from 0 to -40 dB and $\pm 0.5\text{ dB}$ at -60 dB over a temperature range of 20° to 50°C . Averaging and conversion speed is dependent on the AC-DC converter associated with the meter feature, which is required. Operation down to 5 Hz is a minimum requirement.

The log DC outputs from two D22 Series instruments can be used with the differential Y input of an X-Y recorder to provide plots of transmissibility, apparent mass, or mechanical impedance if the appropriate transducers are used. A full output range of 120 dB can be obtained from two 60 dB instruments by using an averaging instrument (UD Model MAC-8) and a servo controller (UD Model SP Series). The combination maintains the average of the two variables at a constant value, but lets both instrument outputs fluctuate and yet never lets either output exceed twice the average control level. It is possible for both outputs to use the full 60 dB range and their ratio to have a maximum 120 dB range.

HIGH-CURRENT LINE DRIVER (C)

The line driver has a capability of $\pm 10\text{V}$ or $\pm 100\text{ mA}$, whichever is limiting, to frequencies of 20 kHz . Capacitive loads may be driven under these limitations without causing oscillations. The frequency response is identical to that for the instrument. The output impedance is less than $0.2\text{ ohm} + .05\text{ ohm/kHz}$. This output may be supplied at a fixed voltage for full-scale inputs, or may be coupled with the TAPE GAIN potentiometer for an adjustable full-scale output.

GALVANOMETER DRIVER (G)

The galvanometer driver is identical to the High-Current Line Driver (C) except that a separately-adjustable 10-turn potentiometer and locking dial is supplied on the front panel to provide a calibrated full-scale output.

VELOCITY (I)

The velocity output has an adjustable sensitivity from 100 to 110 mV-sec/in. Two pole high-pass filtering is built into the velocity integrator circuit to provide a flat frequency response $\pm 2\%$ from 5 Hz to 5 kHz and 3 dB (typ) down at 2.5 Hz . Output impedance is less than 50 ohms and maximum output capability is $\pm 10\text{V}$ at $\pm 10\text{ mA}$. The servo (S) option is required also.

DISPLACEMENT (II)

The displacement output has a sensitivity of 1V/in. D.A. Two-pole high-pass filtering is built into the displacement circuit also. A flat frequency response $\pm 3\%$ at 5 Hz , $\pm 2\%$ 10 to 500 Hz , and 6 dB down at 2.5 Hz is provided. Output impedance is less than 50 ohms and maximum output capability is $\pm 10\text{V}$ at $\pm 10\text{ mA}$. The servo (S) and velocity (I) options are also required.

SINGLE-ENDED HIGH-TEMPERATURE INPUT (K)

The option provides a modification on the D22 charge converter so that single-ended inputs from high-temperature accelerometers may be accepted without causing blocking for input shunt resistances as low as 10 kilohms . Note that the cable for differential accelerometers may be connected to provide a single-ended output to the D22.

Source capacitances of $20,000\text{ pF}$ will cause less than 1% gain change for transducer sensitivities from 1 - 100 pC/g. The frequency response at 5 Hz is flat $\pm 5\%$ with 50 kilohm shunt resistance. The acceleration noise with a 20 Hz ($\pm 2\%$ and -3 dB at 10 Hz) high-pass filter is less than 0.05 pC rms referred to the input.

It is suggested that a choice of the K options be accompanied with the selection of a high-pass filter.

CALIBRATION OSCILLATOR (O)

The internal oscillator provides 100 mV peak $\pm 1\%$ at 100 Hz $\pm 5\%$. When the D22 is placed in any one of the calibration modes (TEST, V-CAL, or F-CAL) the oscillator voltage is applied automatically to the circuit. By means of a rear panel miniature phone jack, the insertion of an external oscillator voltage automatically disconnects the internal oscillator. One calibration oscillator for each six D22 instruments (a full complement for a rack adapter) is sufficient since the output from one internal oscillator may be patched to the other five instruments.

TRACKING FILTER (T)

By means of two rear panel miniature phone jacks, the signal from the D22 may be fed through a unity-gain tracking filter (UD Model TF-11) and back into the D22 so that the D22 outputs (tape; meter; servo; high-current) represent the narrow-band signal. In this way, servo control can be obtained from the fundamental sine component, and the meter indication of the D22 can be used without purchasing additional meters. Removal of the tracking filter from the rear panel jacks automatically shunts the external connection and reroutes the signal properly in the D22.

SWITCHED HIGH-PASS AND LOW-PASS FILTERS

Front-panel-switched high-pass and low-pass filters are standard on the D22PMH. The filters supplied are typically Butterworth, having 3, 6 or 10 poles (18, 36, or 60 dB/oct attenuation). Typical filter specifications are below. The cutoff frequency is f_c .

All Filters -3 dB ± 1 dB at f/f_c
 flat $\pm 2\%$ at $f/f_c = 1$

	HIGH-PASS			LOW-PASS		
Poles	3	6	10	3	6	10
f/f_c	.5	.67	.8	2	1.5	1.25

The $\pm 2\%$ frequency is usually specified.

EXTENDED LOW FREQUENCY RESPONSE (-2)

This option provides the following low-frequency response for charge inputs (strain-gage inputs where applicable) at the servo, tape, high-current and meter outputs.

flat $\pm 2\%$ at 2 Hz
 $\pm 5\%$ at 0.5 Hz

ADDITIONAL (X10) GAIN (-3)

The gain is ten times that of the standard instrument (not available for D22PMR). Standard range switching with this option provides full scale ranges from 0.1 g to 1000 g for transducers with sensitivities from 1-100 pC/g. Note that a transducer with a sensitivity from 10-100 can be used on the 1-10 sensitivity range, thus providing full scale indication for inputs as low as .01 g. Nominal maximum instrument gain is 100,000 mV/pC.

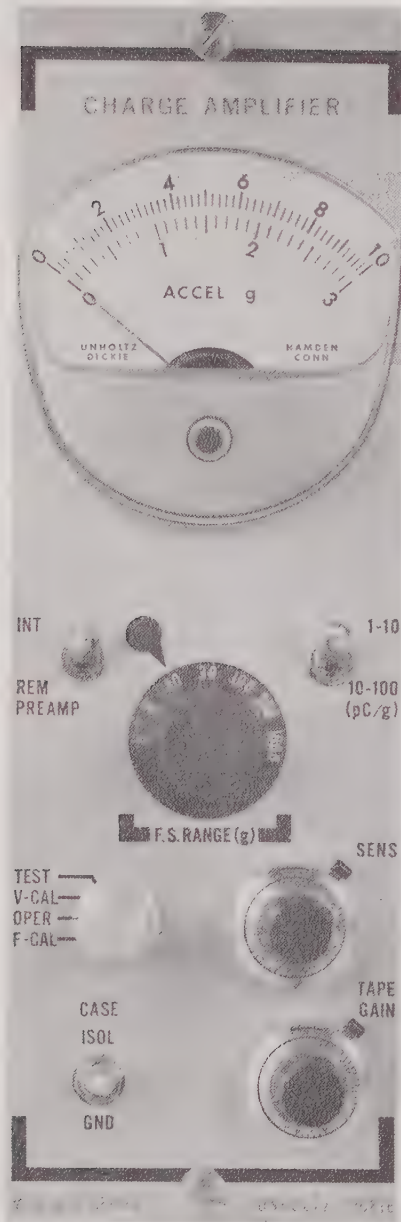
FULL SCALE RELAY CALIBRATION (-4)

Application of the relay control signal (+15V at 15 mA) to the rear-panel BNC connector causes full scale indication at the meter, tape, and high-current outputs, regardless of the range and sensitivity settings, if 100 mV peak is applied to the oscillator jack. This option quite logically accompanies the internal oscillator (O) option, whereupon triggering the relay causes full-scale output. The relay actuation overrides the mode provided by the manual mode switch.

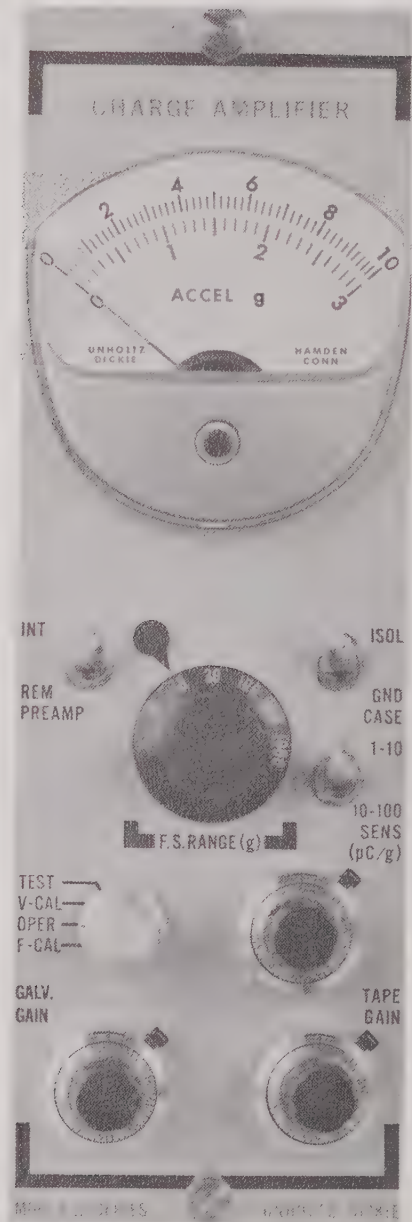
LARGE METER (-8)

A 2.5 in. scale meter is provided with a knife-edge needle for easier reading. Accuracy is $\pm 2\%$ of full scale. The panel height is 8.75 inches and the modules use the Model 22RA-8 Rack Adapter. See figures on page 4.

LARGE METER VERSIONS OPTION -8



MODEL D22PM-8



MODEL D22PMG-8

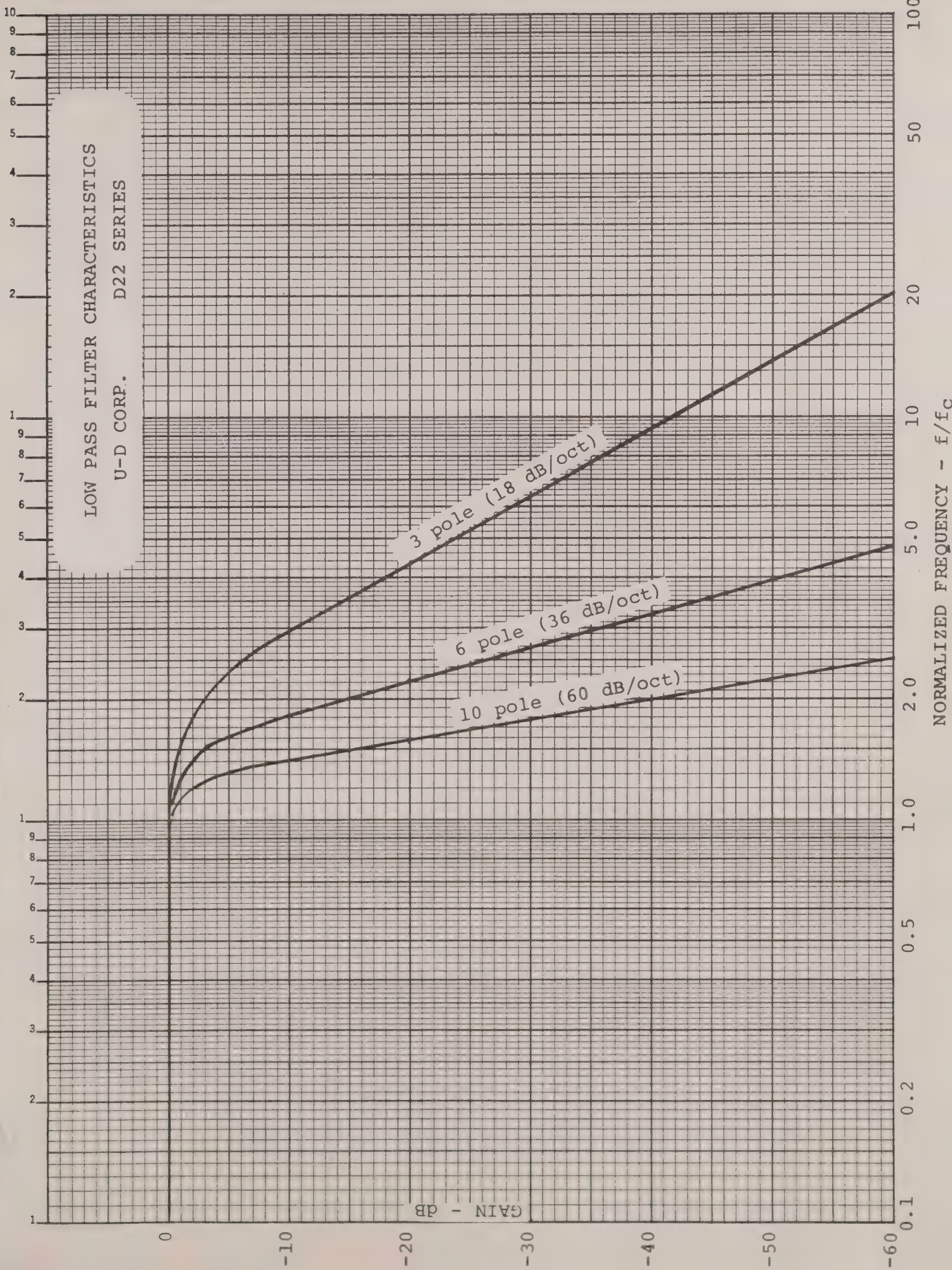
UNHOLTZ-DICKIE CORPORATION

2994 Whitney Avenue, Hamden, Connecticut, 06518

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BULLETIN D22-2-75

LOW PASS FILTER CHARACTERISTICS
U-D CORP. D22 SERIES

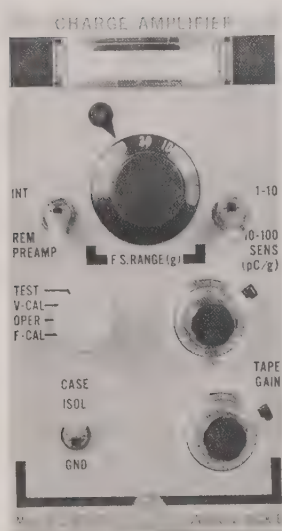


UNHOLTZ - DICKIE CORPORATION

vibration generation systems and measurement instruments

MODEL D22 SERIES SIGNAL CONDITIONING AMPLIFIERS

Three versatile amplifiers with 7 to many options



MODEL D22PM "BASIC"



MODEL D22PMH "RED-HOT"



MODEL D22PMR "MULTI"

A complete redesign and expansion of the signal conditioning line has resulted in amplifiers which satisfy three wide application areas. The D22PM, "Basic", is a charge amplifier which satisfies most standard laboratory needs. The D22PMH, "Red-Hot", is a high-performance charge-amplifier for use with high-temperature (differential) accelerometers. The D22PMR, "MULTI", operates in a charge or voltage mode with piezoelectric devices and in a voltage mode with strain-gage transducers. The circuit design makes extensive use of integrated circuits and plug-in circuit cards, which allow great versatility for adding options. Rugged modular construction allows separate operation or six units to a rack adapter in high noise environments.

COMMON FEATURES OF ALL THREE AMPLIFIERS INCLUDE:

- o Individual shielded power supplies
- o Extreme low-noise operation
- o Wide frequency range 2 Hz - 100 kHz
- o U-D originated DIAL-A-GAIN calibrated sensitivity normalization
- o Calibrated full-scale tape output
- o Differential rejection of ground loop signals
- o Operation with remote preamplifiers
- o Reduced heat load - typically 5 VA
- o Plug-in 3-pole low-pass filters
- o Several Calibration Modes

THE INDIVIDUAL AMPLIFIERS ADD THESE FEATURES:

"BASIC" D22PM

- o Low Cost
- o Guarded Charge Converter
- o Three Calibration Modes
- o Gain insensitive to cable capacitance
- o Options for driving long lines, providing transmissibility plots, controlling servos

"RED-HOT" D22PMH

- o Accommodates single-ended or differential accelerometers
- o Guaranteed noise performance for 50k input shunt resistance
- o Operable to 10k shunt resistance
- o Switchable 3-pole hi-pass and low-pass filters
- o Meter indication

"MULTI" D22PMR

- o Charge or voltage mode
- o Strain gages or piezoelectric devices
- o Simple sensitivity normalization for strain gages
- o Constant-current source for strain gages
- o Internal square-wave gage calibration check

The following table summarizes the outstanding features and helps user selection of options such as meters, log DC output, external range control, and autoranging. The Models D22PMS, D22PMGS, D22PMGSLTO, D22PMHS, and D22PMRS are normally factory stocked for short delivery. Other models are built to order and normally require a minimum order of six units.

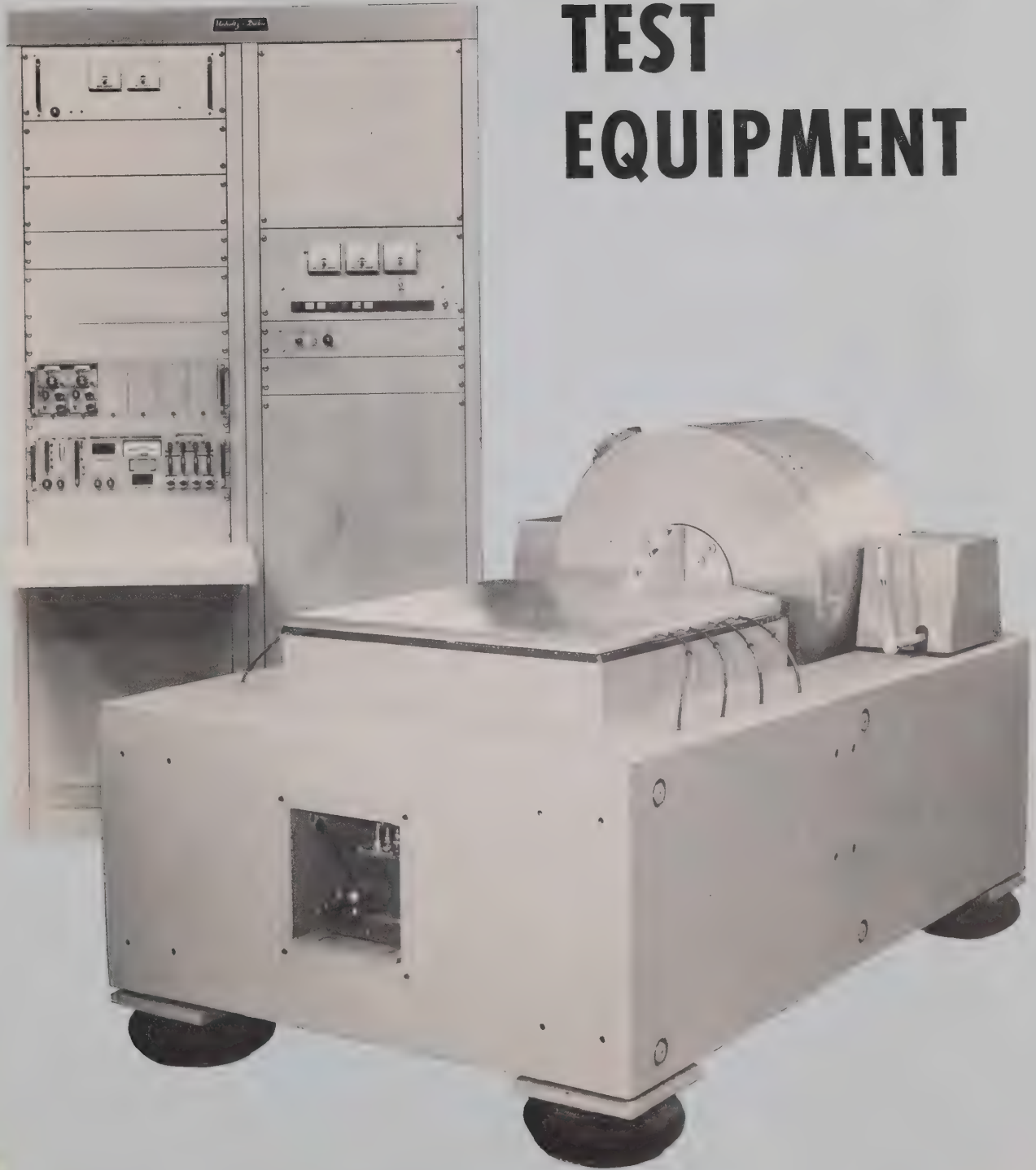
LEGEND: S - Standard O* - Option Factory Stocked Z - Consult Factory For Availability
 O - Available Option N - Not Available

FEATURE/OPTION	OPTION LETTER/NUMBER	"BASIC" D22PM	"RED-HOT" D22PMH	"MULTI" D22PMR	COMMENTS
Ground Loop Signal Rejection	D	S	S	S	
Internal/Remote Preamp	P	S	S	S	
Meter-Edge Reading $\pm 2\%$ F.S.	M	S	S	S	
1-10, 10-100 Sens. Ranges	-	S	S	S	
10 Turn Locking Sens. Pot	-	S	S	S	U-D Dial-A-Gain
10 Turn Tape Gain $\pm 10V$ F.S.	-	S	S	S*	* $\pm 1V$ F.S.
Fixed Plug-In LP Filter	-	S	N	S	3-Pole Butterworth
In/Out Switch LP Filter	-	N	S	N	6 & 10 Pole Also Available
In/Out Switch HP Filter	-	N	S	N	6 & 10 Pole Also Available
Test, F-Cal, V-Cal Modes	-	S	S	N	
Diff. Accel. (Hi-Temp) Input	H	N	S	N	Includes K
Single Ended Hi-Temp Input	K	O*	S	O*	
Strain Gage, Charge, Volt Input	R	N	N	S	
10 mV/g Servo Output	S	O*	O*	O*	
100 mV-sec/in. Vel. Output	I	O	O	O	Requires S
1 V/in. DA Disp. Output	II	O	O	O	Requires S & I
Linear DC Output	F	O	O	O	
Log DC (1V/20dB) Output	L	O	O	O	Requires M
Manual Ranging 1-3-10 F.S.	-	S	S	S	
Remote Range Control (2 line)	E	O	O	O	4 Decade Ranges
Automatic Range Selection	A	O	Z	Z	Includes E, Requires M
High Current Line Driver ± 100 mA	C	O	O	O	Current Booster For Tape Out
Independent Galvo Output ± 100 mA	G	O*	N	N	Adjustable with 10T Pot.
Calibration Oscillator	O	O	O	O	100 mV pk at 100 Hz
Tracking Filter	T	O	O	O	Allows internal insertion
Freq Resp $\pm 5\%$ 2Hz to 30 kHz	-	S	S	S	
Extended Low Freq. $\pm 5\%$ 0.5 Hz	-2	O	O	O	
Extra X 10 Gain	-3	O	O	N	.01 g F.S. For 10-100 Sens
Full-Scale Relay Calibration	-4	O	O	O	
Large $2\frac{1}{2}$ " Scale Meter	-8	O	Z	Z	8.75 In. Panel Height

UNHOLTZ-DICKIE CORPORATION

2994 Whitney Avenue, Hamden, Connecticut, 06518

VIBRATION TEST EQUIPMENT



UNHOLTZ - DICKIE
CORPORATION

Vibration testing has been a major tool used in the development of military and space hardware for over 25 years. Today, the benefits of vibration testing are being applied in a variety of commercial and consumer product areas as well. This trend parallels an increasing number of federal regulations which require more comprehensive testing to assure product reliability and safety.

Vibration testing can genuinely benefit the manufacturer. By simulating environmental vibration levels during actual product development, the engineer can verify that a design is suitable for its application. This type of testing establishes performance and reliability prior to release of a design for production. Such an approach can save money by minimizing the probability of major redesign work, and even legal liabilities which may result from an inadequate product design. In addition, quality control procedures can be enhanced by using vibration testing as a tool to monitor the consistency of production methods and materials.

Electrodynamic shaker systems are used in a variety of test applications. A typical arrangement for automatic sine testing is shown in FIG. 1. Such a setup provides automatic frequency cycling at preselected vibration levels, under servo control. A typical test "program" is shown in FIG. 2.

Figure 2. EXAMPLE OF TEST PROGRAM

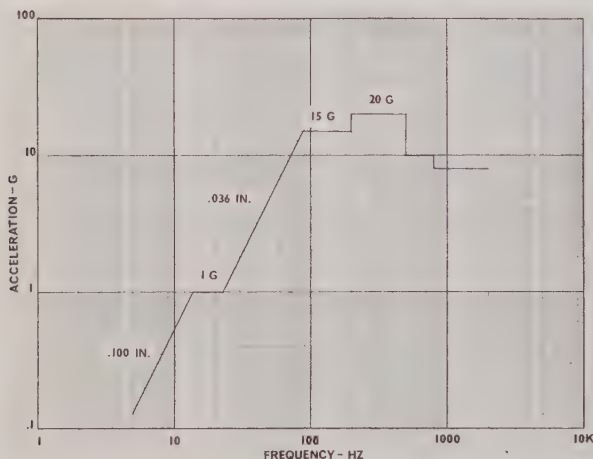
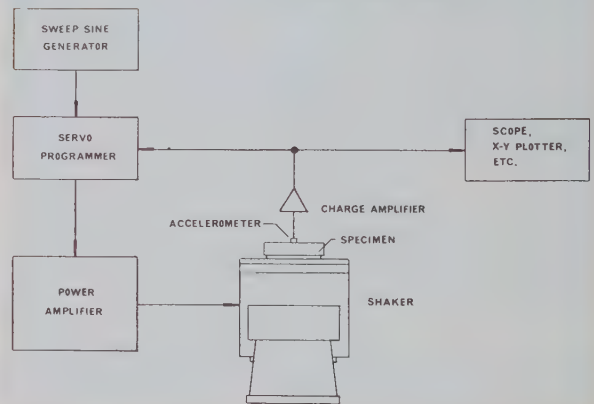


Figure 1. SETUP FOR AUTOMATIC SINE TESTING



The block diagram above could represent any of a wide variety of available vibration test systems. Unholtz-Dickie, the industry leader in solid state powered shaker systems, offers a complete line of vibration test systems as well as a full complement of signal conditioning and control instrumentation. See page 3 for a convenient listing of Unholtz-Dickie shaker systems. The remaining pages describe many of the instruments and system accessories that have helped make Unholtz-Dickie today's number one manufacturer of vibration test equipment.

CONTENTS

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★ VIBRATION TEST SYSTEMS	3 - 7
★ CONTROLS	8 - 9
★ INSTRUMENTATION & MEASUREMENT	10-12

VIBRATION TEST SYSTEMS

Unholtz-Dickie produces vibration test systems for all test applications. Sine force ratings range from 50 including those with multiple shakers are also available. to 24,000 pounds. The table below lists these systems, with pertinent technical data. Special systems,

Every Unholtz-Dickie system includes a proven solid state power amplifier, and features reliable air cooling of the shaker armature. Systems engineering of each system component assures maximum performance and utilization, with simplified operation.

SYSTEM PERFORMANCE				SHAKER	
FORCE (lbs)		STROKE (inches, DA)	MAX. SINE PAYLOAD (lbs) at 20g	ARMATURE WEIGHT (lbs)	TABLE DIA (inches)
Sine (pk)	Random (rms)				
50	—	0.5	1.8	0.69	2
50 ¹	—	1.0	1.9	0.55	DRIVE ROD
150 ¹	—	4.0	5.2	2.25	DRIVE ROD
250	125	1.0	9.7	2.75	3.5
300	180	1.0	12.2	2.75	3.5
500	300	1.0	19.7	5.3	4.5
1,000 ¹	—	6.0	39	11	DRIVE ROD
1,200	600	1.0	46	14	5.75
1,200	600	1.0	40	20	8
1,700	850	1.0	71	14	5.75
1,700	850	1.0	65	20	8
3,000	2,200	1.0	134	16	5.75
3,000	2,200	1.0	128	22	8
4,000	3,300	1.0	171	29	8
6,000	3,000	1.0	264	36	12
6,000	4,500	1.0	264	36	12
7,000	4,000	1.0	300	50	12
7,000	5,500	1.0	300	50	12
8,000	4,000	1.0	310	90	16
9,500 ²	4,500	1.0	375	100	16
10,000	5,000	1.0	400	100	16
10,000 ²	6,500	1.0	405	95	16
12,000	6,000	1.0	510	90	16
12,000 ²	8,000	1.0	500	100	16
15,000 ²	9,500	0.75 ³	650	100	16
17,500 ²	12,000	1.0	780	95	16
19,000 ²	15,000	1.0	855	95	16
20,000 ²	14,000	1.0	905	95	16
22,000 ²	18,000	1.0	1,005	95	16
24,000 ²	20,000	1.0	1,105	95	16

NOTES:

¹ MODAL SYSTEMS (See PAGE 7)

² INDUCT-A-RING SHAKER (SEE PAGE 5)

³ 1.0 INCH STROKE AVAILABLE WITH REDUCED
FORCE RATING

SHAKERS

U-D shakers range in size from small, portable units for component-type testing, up to large machines for high performance testing of relatively massive specimens.

These shakers are generally categorized by a SERIES number, which indicates a basic frame size. Typical shaker models in the various SERIES are shown here. Special long-stroke shakers designed for "modal testing" are described on page 7.

SERIES 100

Max. Force Rating: **50 pounds** peak sine. For small component testing, especially to high frequencies. Portable. **Air cooled.**



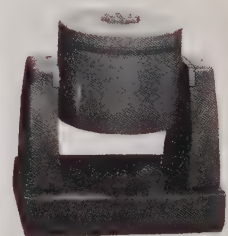
SERIES 200

Max. Force Rating: **300 pounds** peak sine. For component and sub-assembly testing. Can also be used in modal work. Portable, **Air cooled.**



SERIES 300

Max. Force Rating: **500 pounds** peak sine. For component and sub-assembly testing. Also used in Transducer Calibration Systems (page 7). Water cooled field. **Air cooled armature.**



SERIES 500

Max. Force Rating: **1,700 pounds** peak sine. Available with 5 $\frac{3}{4}$ " and 8" diameter tables. **Air cooled.**



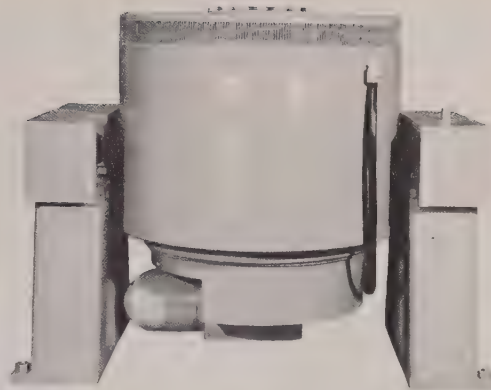
SERIES 1000

Max. Force Rating: **4,000 pounds** peak sine. For testing of small components up to major assemblies. Available with 5 $\frac{3}{4}$ " and 8" diameter tables. **Air cooled.**



SERIES 500

Max. Force Rating: **7,000 pounds** peak sine. Available with a light weight armature for high g testing, or heavier armature for more massive specimens. **Air cooled.**

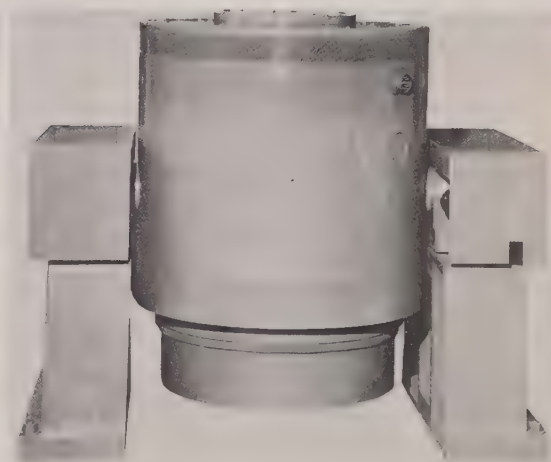


SERIES 1000

Max. Force Rating: **12,000 pounds** peak sine. U-D's largest wound-coil shaker. For testing small assemblies up to massive specimens. Water cooled field. **Air cooled armature.**

SERIES 1000W

Max. Force Rating: **24,000 pounds** peak sine. Features U-D's exclusive INDUCT-A-RING armature design (see below). For reliable, ultra high performance testing of small assemblies up to massive specimens. Water cooled field. Water or air cooled stators. **Air cooled armature.**



INDUCT-A-RING ARMATURE

INDUCT-A-RING is the U-D trade name for a revolutionary armature design concept. The principle of transformer action is utilized to transfer energy from stationary AC driver coils (stators) to a moving element.

- The moving element is a simple two-piece metal structure. A single turn, solid metal armature coil is bolted metal-to-metal to the shaker table casting, providing the ultimate in strength and rigidity.
- All points on the vibrating member are at ground potential (zero voltage) at all times. There are no electrical windings or epoxy bonded joints. There is **no possibility of voltage breakdown**, and therefore no insulation is required.
- The solid metal, single turn ring is **air cooled**. Cooling connections subject to armature vibration are eliminated.
- AC currents are induced into the solid metal ring, **eliminating electrical connections** which bridge stationary and moving parts.

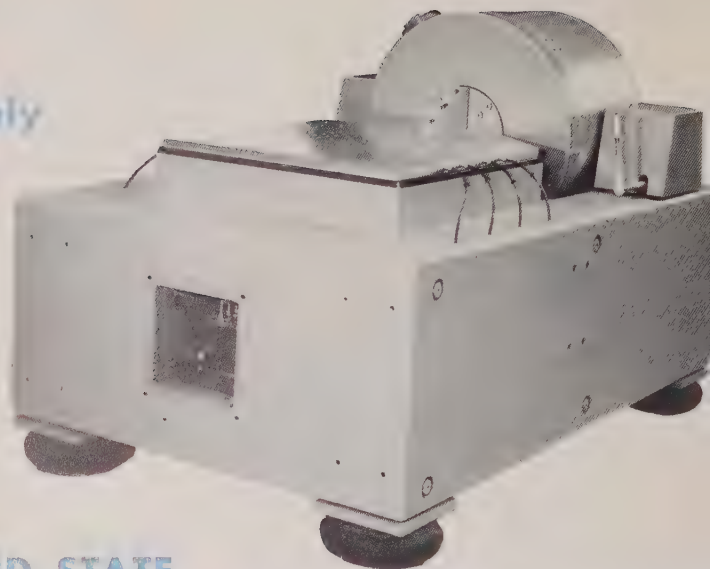
The INDUCT-A-RING armature is featured in 1000W SERIES shakers, rated up to 24,000 pounds peak sine force.



CSTA

Combined Slip Table Assembly

The **PERMALINE Combined Slip Table Assembly** provides for testing in three axes while using only one fixture. Permanent factory alignment of the shaker and slip plate allows quick change from vertical to horizontal operation. In addition, no special floor construction is required since inflatable air mounts effectively isolate the entire assembly from the supporting structure.



SOLID STATE POWER AMPLIFIERS

U-D pioneered the use of solid state power amplifiers to drive electrodynamic shakers in the early 1960's. Advances in silicon technology have been combined with proven circuit designs to produce the present generation of amplifiers. This design has demonstrated reliable performance in hundreds of customers installations since its introduction in 1968. U-D's industry leading position as a supplier of solid state power is clearly demonstrated by the fact that U-D has delivered more kVA of solid state power than all other competitors combined. Over eight years of field proven reliability stand behind every U-D solid state power amplifier — a record unmatched in the industry.

EXPANDABLE, MODULAR DESIGN

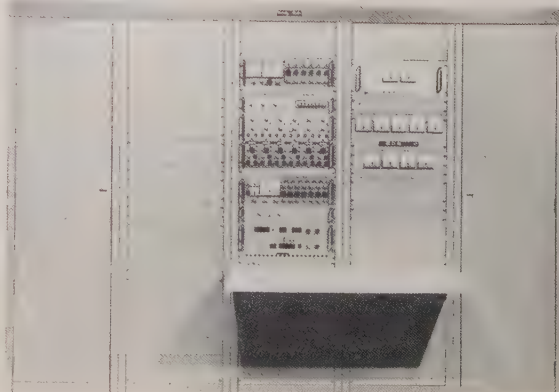
The basic power amplifier architecture provides for field expansion to higher output ratings. A given amplifier has one or more 16 kVA Output Assemblies. Amplifier expansion is accomplished simply by adding the required number of Output Assemblies to the predrilled mounting hardware.

EASILY ACCESSIBLE OUTPUT CIRCUITRY

All output power transistors are stud mounted in massive water cooled heat sinks. Amplifier shutdown or drainage of cooling water are not required to perform routine maintenance checks of the complete amplifier circuitry. All transistor terminals are physically accessible, permitting test point monitoring of individual transistors during actual amplifier operation.

SIMPLIFIED, RELIABLE WATER COOLING

The amplifier finals are premium grade, silicon alloy junction power transistors which are widely recognized for their nonaging ruggedness. The transistor collector is common to a threaded mounting stud, permitting direct contact between the stud and cooling water flow. The water cooled heat sink is designed to provide optimum turbulence around the transistor stud and mounting base. This design assures maximum cooling efficiency while retaining relatively large water passages.



128 kVA Solid State Power Amplifier
and System Control Console

MODAL SHAKER SYSTEMS

Unholtz-Dickie manufactures a family of shakers designed specifically for "modal" testing. These shakers feature long stroke, low internal damping, and near zero axial spring rate. These special characteristics facilitate the excitation of pure structural modes, especially when multiple shaker arrays are utilized. The shaker moving element includes a hardened output shaft for connection to the test object.

These modal shakers incorporate a double ended field structure, providing parallel flux paths from above and below the magnetic air gap. This design gives maximum magnetic flux linkage with the armature coil, and assures optimum waveform purity. Uniform flux density throughout the operating stroke provides output force proportional to armature current, independent of armature position.

When driving power is provided by a U-D solid state power amplifier with "current feedback," these shakers can be operated as **constant force** generators. In this operating mode, shaker armature current is proportional to power amplifier input voltage through large variations of load impedance; therefore, the magnitude of the generated AC force in the armature coil remains constant as a function of frequency. This constant force characteristic also requires the shaker to have a "force/armature current" ratio reasonably independent of armature position, as described earlier. Constant force sweeps can be performed without force links, external servos, or tracking filters.

Three basic models are available. The Model 1 is a 50 pound force, permanent magnet design with a one inch stroke. The Model 4 is a four inch stroke shaker rated up to 150 pounds force. Both of these units feature folding-type carrying handles which enhance portability.

The Model 6 Shaker generates up to 1000 pounds force and provides a full six inch stroke. This shaker is frequently used to generate low frequency motion in seismic simulation studies, or for vehicular studies in aerospace applications.



MODEL 4

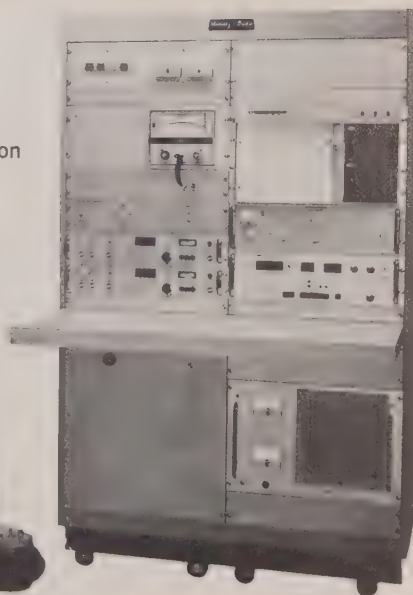
SERIES 300 VIBRATION TRANSDUCER CALIBRATION SYSTEMS

The Series 300 Calibration Systems are offered with manual controls for point by point calibration, or with frequency sweeping controls giving an automatically drawn curve of % deviation of the "unknown" transducer sensitivity relative to the "reference" accelerometer, as a function of frequency. Original data is permanently plotted, eliminating operator errors in readout and transcription.

At full system performance, and with automatic servo controls operating, acceleration waveform distortion is less than 1.5% at all operating frequencies. The overall system noise level is less than .005 g rms. Automatic plotting systems feature 0.25% plotting resolution of the unknown transducer output relative to the reference.

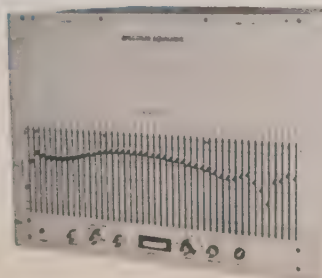
Model 351

Automatic Recording Vibration Calibration System with Optional VI100 Shaker Vibration Isolation



RANDOM ACCESSORIES

Complete random testing capability is available with systems-engineered random accessories. A typical remote random control console configuration is shown here.



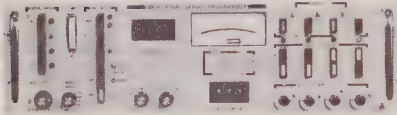
Random Accessories include the Model E109B Spectrum Equalizer, featuring 45 active filters with individual, rectilinear motion attenuation controls. Convenient equalization can be performed using this unit in conjunction with a real time analyzer.



AUTOMATIC SINE CONTROLS

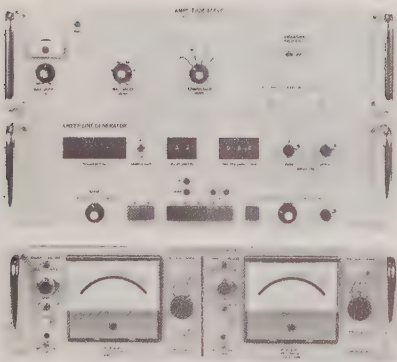
Three automatic sine control systems are available. Each is a complete control system, including everything necessary to conduct sophisticated sinusoidal vibration tests. Each control system includes a **zero static error servo**. This feature allows large gain changes in the compressor (AGC) circuitry without introducing static errors in the actual control level. Many other desirable features are described below. Select the control combination which best fits your requirements.

BASIC



The **OSP-4 Oscillator-Servo-Programmer** is our most economical, compact sine control system. This unit combines the following features in a single chassis: a sweeping digital sine generator, frequency counter, vibration meter, servo control, four-level programmer, and input charge amplifier. Frequency range: 5 to 5,000 Hz.

LOW FREQUENCY

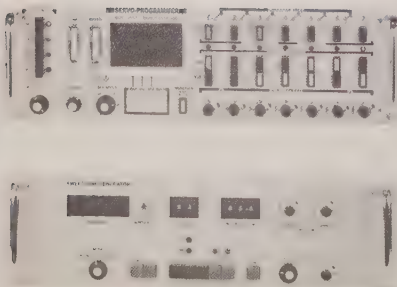


Superior low frequency control is provided by the **OSC-1L Sweep Sine Generator** and **SP-2L Servo Programmer**.

The **OSC-1L** is a sweeping digital sine generator which operates from 1 to 5,000 Hz. A built-in frequency counter samples and displays ten times per second even at 1 Hz. Sweep rate and number of sweeps may be preselected to provide automatic test shutdown.

The **SP-2L** is a low frequency, 2-level servo which operates from 1 to 5,000 Hz. This unit is designed for use with the 2610RM-1 dual channel signal conditioner which provides precision readout for each program level. Servo control on acceleration, velocity or displacement to 1 Hz is provided, using the 100PA Accelerometer. The 100PA also permits high frequency operation to at least 2,000 Hz.

DELUXE



The most comprehensive sine control system available in the industry consists of the **OSC-1S Sweep Sine Generator** and **SPA-7 Servo Programmer**.

The **OSC-1S** is a sweeping digital sine generator which operates from 2 to 5,000 Hz. A built-in digital frequency counter reads and displays ten times per second even at 2 Hz. Sweep rate and number of sweeps may be preselected to provide automatic test shutdown. A sawtooth generator output permits synchronous scope display of the vibration waveform.

The **SPA-7** is a programmable seven-level servo. Digital display of acceleration, velocity or displacement is provided, plus automatic or manual modes for selecting the crossover frequency between program segments. An input charge amplifier is standard.

SPECIAL CONTROLS



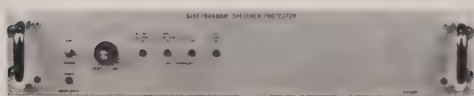
Model RD-1 Resonant Dwell Control automatically maintains the vibration testing frequency at the resonant frequency of a test specimen during fatigue testing.



Model MAC-8 Multifunction Averaging Control features eight individually selectable data channels for control to the average signal level. Can be used for sine or random vibration testing.



Model ACS-6 Acceleration Control Selector automatically switches to the highest (or lowest) acceleration input. Accepts up to six acceleration signals, and gates to the output whichever signal reaches its preset limit.

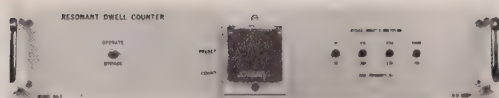


rapidly — as rapidly as 100 microseconds, depending on the operating frequency at the time of shutdown.

Specimen protection limits are defined by presetting a group of system interlock sensors, which monitor such parameters as amplifier voltage, amplifier current, and shaker stroke. Each sensor can be adjusted to function at two discrete levels. The **first** setting of each sensor is adjusted to trip at some increment above the normal maximum operating level of a given test. This first level activates the amplifier input compressor. If compression removes the "overtest" condition, no further shutdown sequencing occurs. The amplifier remains on the air, but with essentially zero input signal.

If this first compression sequence does not remove the overtest condition, a complete amplifier shutdown sequence is initiated as soon as any of the interlock sensors reaches its **second** preset limit. The complete shutdown sequence consists of the following action: 1) compression is again triggered if not already complete; 2) output power transistors are disconnected from the preamplifier; 3) main power contactors are released. This final shutdown function is designed specifically to prevent contactor transients from reaching the amplifier finals.

The SRP-3 Protection System operates for sine or random testing, and is optionally available on new vibration test systems. Consult factory for further details.



Model RD-2 Resonant Dwell Counter indicates the number of stress cycles accumulated by a specimen undergoing a resonant dwell test. Counter may be preset to initiate automatic shutdown after completion of desired number of stress cycles.

Model TF11 Tracking Filter provides constant 10% bandwidth or fixed 2 to 200 Hz bandwidth filtering, plus a log DC output for X-Y plotting. Economical, modular construction.



Model AM-123 Vibration Monitor/Limiter offers independent overtest protection for shaker systems. Adjustable shutdown limits are provided for both acceleration and displacement. Protection circuits operate for sine or random testing and provide soft, rapid shutdown.

The Model SRP-3 Sine/Random Protection System provides **comprehensive** protection for vibration test specimens. Variable speed signal compressor circuitry is connected to the power amplifier input. This compressor automatically reduces the amplifier input signal to zero whenever amplifier shutdown is imminent. Compression is performed smoothly yet

D22 SERIES

The D22 Series provides charge amp signal conditioning for all piezoelectric transducers. Some models also provide for strain gage operation. This series features all integrated circuit design with superior low noise characteristics, in a rugged modular construction. The basic Model D22PM includes the capability of operating with a remote preamp, and includes a meter. This and other standard models are shown below. The wide range of optional features available for addition to most models, is listed below.

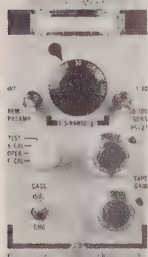
D22 OPTIONS

Description

STRAIN GAGE OPERATION
HIGH TEMP ACCEL. INPUT
BRIDGE CONDITIONER
10 mV/g SERVO OUTPUT
100 mV-SEC/IN. VEL. OUTPUT
1 V/IN. DA DISP. OUTPUT
LINEAR DC OUTPUT
LOG DC OUTPUT
REMOTE RANGE CONTROL
AUTORANGING
 ± 100 mA LINE DRIVER
 ± 100 mA GALVO OUTPUT
CALIBRATION OSCILLATOR
TRACKING FILTER CONNECTION
0.5 HZ FREQ. RESPONSE
EXTRA X10 GAIN
FS RELAY CALIBRATION
LARGE $2\frac{1}{2}$ " SCALE METER

Suffix

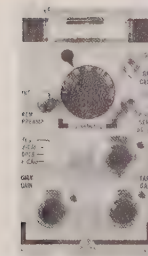
R
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-4
-8



D22PM



D22PMH



D22PMG



D22PMA



D22PMR



D22PMB



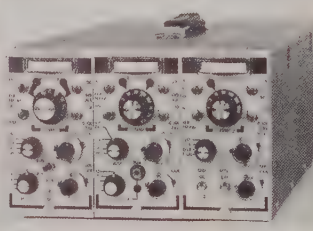
D22PMGA



P22M



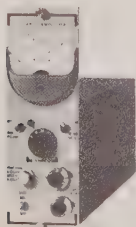
22RA



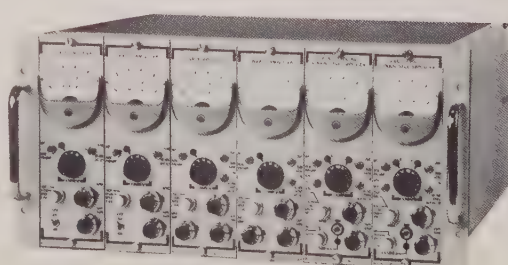
22P3

The Model 22RA Rack Adapter accepts six 22 Series modules in the standard $5\frac{1}{4}$ inch panel height. Also accepts the Model TF11 Tracking Filter (see page 9).

The Model 22P3 Three Channel Portable Adapter accepts three channels of 22 Series instruments.



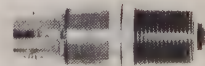
D22PM-8



22RA-8

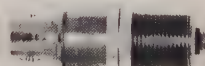
Models D22PM and D22PMR are available with the "-8" option, which provides a $2\frac{1}{2}$ inch meter scale for easier readout.

Rack mounted D22's with the "-8" large meter option require the 22RA-8 Rack Adapter with $8\frac{3}{4}$ inch panel height. Each 19 inch adaptor accepts six "-8" modules.



11PA-2

The Model 11PA-2 is a two-wire Remote Voltage Preamp designed for use with any of the 22 Series instruments.



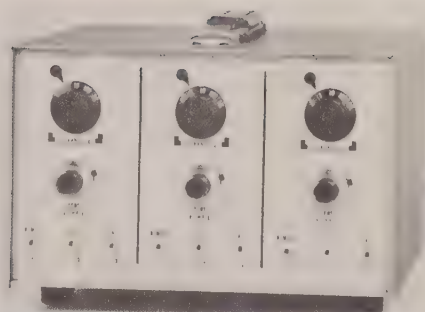
22CA-2

The Model 22CA-2 Remote Charge Preamp may be used with any of the 22 Series instruments shown above and is a companion unit to the Model P22M. Optional Model 22CA-2T is available for operation to 160°F .

SIGNAL CONDITIONERS



Model 1610M Portable Vibration Monitor can be used with any piezoelectric accelerometer with 1 to 100 pC/g sensitivity. Monitors acceleration, velocity, or displacement with log scale meter read-out and switch selectable outputs. Also available in single and dual channel rack mount versions.



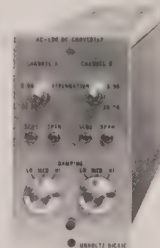
Model 322 Signal Conditioner consists of a three channel charge amplifier for basic, simplified operation with piezoelectric accelerometers, two wire remote preamps, or two-wire industrial accelerometers. A 1 volt full scale output is provided for each channel.



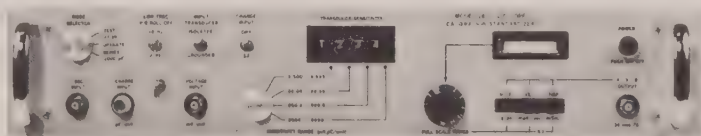
Model AVD-22M provides two channel, double integration of conditioned 10 mV/g acceleration signals. Each channel has tape and X-Y plotter outputs, plus normalized velocity and displacement outputs. Unit features 80 dB dynamic range and switchable low frequency filtering.



Model CV22PM-LF1 charge/voltage amplifier, operates down to 0.1 Hz. Combines capabilities for low level, low frequency vibration measurements and long duration shock pulse measurements.



Model LDC-22 provides two channel conversion to log DC of conditioned 1V peak full scale input signals for X-Y plotting. Features 5-10,000 Hz frequency response, 60 dB dynamic range, and selectable damping.



Model 1611 Precision Charge/Voltage Calibration Standardizer features typical 1/4 percent overall instrument accuracy and stability. Frequency response from 2 Hz to 20,000 Hz. Used in transducer calibration systems, or wherever maximum accuracy is required.



Model SA22 Shock Charge Amplifier measures shock pulse durations from 100 microseconds to 500 milliseconds and pulse amplitudes up to 100,000 pC peak.

Model 2216 Signal Conditioner is a low cost, modular instrument for use with the Model 100PA or 1000PA Accelerometer. Permits acceleration measurements down to 0.1 Hz with less than 30 micro g residual noise.



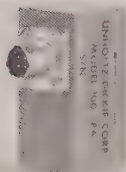
ACCELEROMETERS

Unholtz-Dickie produces a full line of piezoelectric accelerometers for general purpose vibration testing and for many special applications. Subminiature, light weight models are offered for high frequency requirements. High sensitivity models give maximum signal/noise ratios for low level measurements.

The **Model 10B10** and **10B10T** feature a factory adjusted sensitivity of exactly 10 pC/g. This convenient normalized sensitivity allows multi-channel charge amplifier configurations to be set for one input sensitivity, which then permits complete accelerometer interchangeability. Thus, a major source of instrumentation error can be eliminated.



10B10T



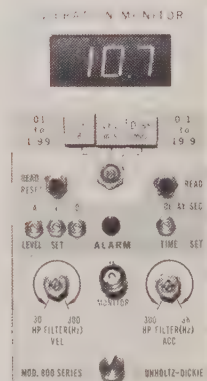
100PA

The **Model 100PA** is a 100 mV/g, low output impedance accelerometer that is particularly well suited for wide dynamic range acceleration measurements and reliable, low level displacement measurements requiring double integration. Accurate, low level displacement data at 1 Hz is easily obtainable. The 100PA is typically used with the 1610M Vibration Monitor or 2216 Signal Conditioner (page 11).

INDUSTRIAL VIBRATION MONITORING

The **U-D 8800 Series Industrial Accelerometer** and **800 Series Vibration Monitor** represent a thoroughly engineered sensor/instrument system for machinery health monitoring. Monitoring is accomplished with the low output impedance 8800 accelerometer featuring simple installation and a rugged two-wire cable, plus the modular 800 Series Vibration Monitor.

The **8800/800 Series** approach takes unique advantage of the TOTAL vibration spectrum by placing equal emphasis on **displacement** measurements in the lower frequency range, **velocity** measurements in the mid-frequency range, and **acceleration** measurements in the high frequency range. Simultaneous monitoring of all three vibration parameters utilizes information that is essentially wasted by proximity probes or velocity pickups.



8803

841B

The **Model 1602 Transducer Tester** is a single frequency, portable test stand which may be used to verify the operation of any vibration transducer. An internal reference accelerometer is utilized to monitor actual test table motion, which is displayed in terms of acceleration, velocity, or displacement on a convenient digital readout. Driving power and controls are self-contained. The dynamic response of the test table can be "tuned" to give maximum response with different table loads. Thus, a wide range of transducer weights may be accommodated.



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Vibration Testing Equipment

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HAMDEN, CONN. 06518

MAIN OFFICE: HAMDEN, CT
(203) 288-3358

WEST COAST OFFICE (213) 378-9418
1926 SOUTH PACIFIC COAST HIGHWAY
REDONDO BEACH, CA 90277

WARRANTY

All products are warranted to be free of defects in material and workmanship for a period of one year from date of shipment. If the product is not installed, maintained and used in a normal manner in accordance with instructions and manuals, this warranty will not apply. Commercially available instruments and accessory items purchased and installed in the product will carry the original manufacturer's warranty.

This warranty is limited to repairing or replacing parts which have been returned and in our opinion are defective. Service required to correct defects in material or workmanship will be supplied without charges. The Buyer will pay all transportation and taxes incurred. This warranty does not cover any costs incurred by the Buyer as a result of purchase of UNHOLTZ-DICKIE CORP. equipment or any charges for the Buyer's labor for replacement, adjustment or repair unless authorized in advance in writing. We are not liable for consequential damages.

This warranty will not apply to any products which, in the opinion of UNHOLTZ-DICKIE CORP., have been subject to accident, misuse or neglect; altered or repaired with a substitute which might impair the product; or used outside of rated conditions. UNHOLTZ-DICKIE CORP. reserves the right to make improvements in its products including changes and additions without incurring obligations to incorporate such improvements in previous units.

This warranty is expressly in lieu of any and all other warranties or commitments, expressed or implied and any other obligations to the Buyer associated with the use of UNHOLTZ-DICKIE CORP. products.

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Incoming Instrument Inspection and Return Shipping Instructions

1. Unpacking and Inspection

If the shipping carton is damaged, note on acceptance that it is received damaged and subject to claim when inspected. Ask that the carrier's agent be present when the instrument is unpacked and inspected for damage (scratches, dents, broken knobs, etc.). If the instrument is damaged or fails to meet specifications, notify the carrier and the Unholtz-Dickie Corporation immediately. Retain the shipping carton and the padding material for possible return for repair or further inspection by carrier. The purchaser and Unholtz-Dickie Corporation will arrange for the replacement and/or repair of the damaged item.

Refer to our separate warranty page for a statement of our warranty policy.

2. Return Shipment

Return shipment procedure: Please be sure the following instructions are observed if a Model 22 Series instrument is being shipped back to Unholtz-Dickie for repair, replacement, or upon completion of use as a demonstrator or loaner.

2.1 Size of Box and Packing Instructions

2.1.1 Single Channel with 5½ inch Panel Height

If the single channel was shipped from Unholtz-Dickie as an individual unit, replace the instrument in its original container. If the instrument was shipped as part of a rack mounted combination of channels, the single channel can be returned separately in a container that is no smaller than 22½ inch x 10½ inch x 9½ inch. The front and rear panels must be completely protected by approximately 2 inches of cushioning material. The top, bottom and sides must be surrounded by cushioning and filler materials. A strong, double wall type corrugated box, (350 lb/sq. in. minimum bursting test) has been proven to give adequate service. DO NOT USE A SMALLER OR WEAKER CONTAINER THAN THAT RECOMMENDED ABOVE.

Cover the painted surfaces of the instrument with protective wrapping paper or a plastic bag whenever the packing material might be coarse enough to scratch the painted surfaces.

2.1.2 Six Channel Rack with 5½ inch Panel Height

CAUTION: Do not rest the rack type instrument in a vertical position with its weight on the rear since the connectors and switches at the rear of the instrument might be damaged.

Replace this instrument in the original container. Replace all packing pads and fillers in the exact position which they originally occupied. If the original container is no longer available, use a container that is no smaller than 27 inch x 20½ inch x 10½ inch.

It is important that protection be provided for the rear connectors and switches during shipment. A sheet of stiff cardboard should be placed under the instrument and then folded up to meet the top of the rear panel. The instrument should be bagged and surrounded on all surfaces by cushioning and filler materials. A strong, double wall type corrugated box (350 lb/sq. in. minimum bursting test) has been proven to give adequate service. DO NOT USE A SMALLER OR WEAKER CONTAINER THAN THAT RECOMMENDED ABOVE.

2.1.3 Single Channel with 8-3/4 inch Panel Height

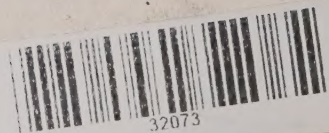
Follow the instructions given in paragraph 2.1.1, except that extra precautions must be taken to prevent the front panel extension with its meter from being bent during shipment. The extended meter must be braced between packing material so that the load force will be distributed evenly over the entire front panel of the instrument.

2.1.4 Six Channel Rack with 8-3/4 inch Panel Height

Follow the instructions given in paragraph 2.1.2, except that the container size must be no smaller than 26½ inch x 25 inch x 13½ inch.

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